Soybean Insects: Identification and Management in Illinois

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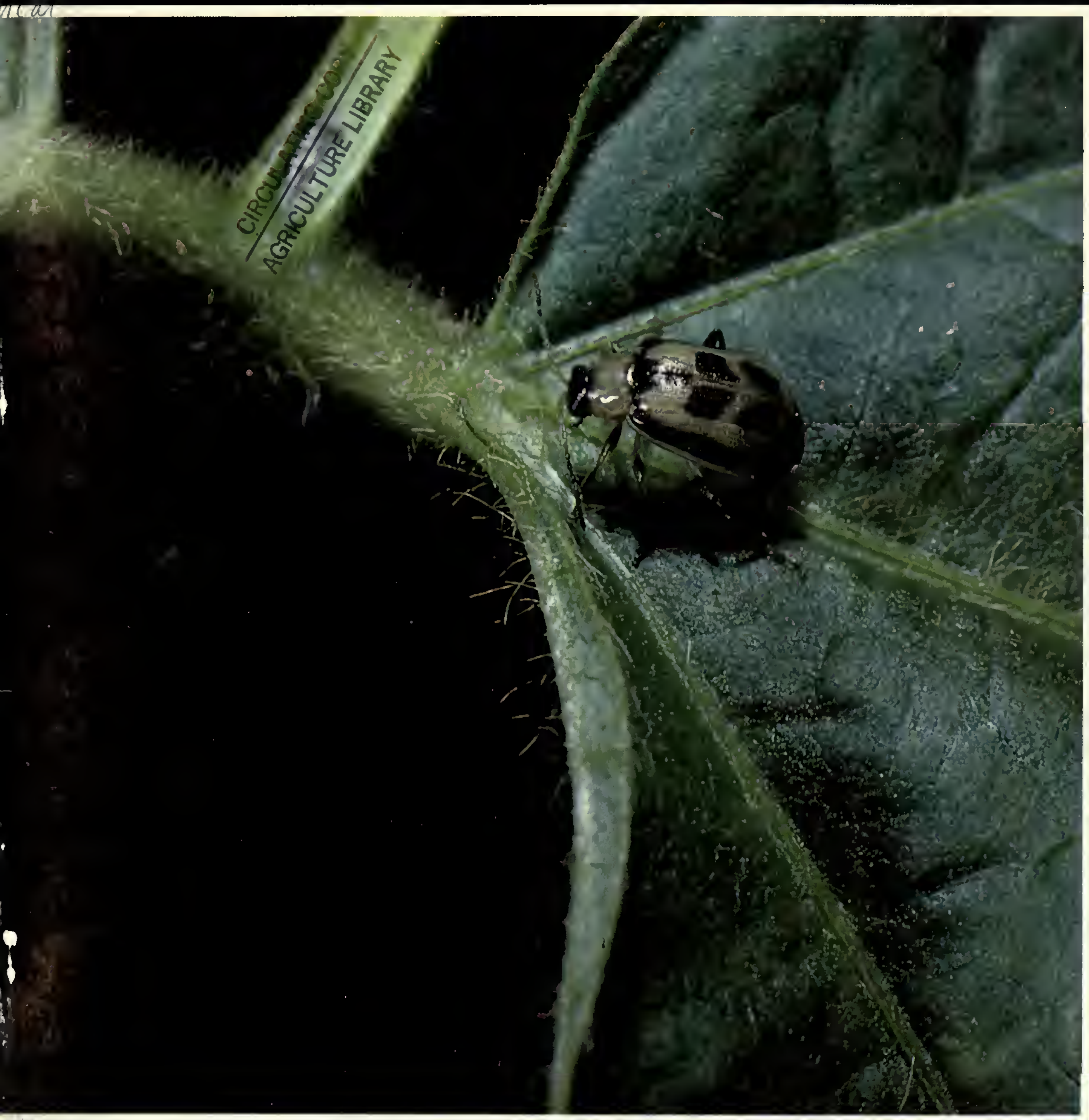

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Contents

Abstract

Key words: Control decisions, cropping system, economic thresholds, host plant resistance, illustrated keys, insect pests, life cycle, natural enemies, pest management, plant injury, sampling methods, soybean

A program for managing soybean insect pests is presented. This program requires identification of pests and their natural enemies and methods for measuring pest populations and injury. Illustrated keys aid in identifying symptoms of plant injury and the associated pests. Descriptions of the pests and their life cycles follow the keys. Life cycles of the main pests are presented in relation to the growth cycle of the crop. Sampling procedures for the main pests are described. The program is based on estimates of economic damage thresholds at various stages of plant growth. Decision charts outline appropriate management practices in relation to thresholds. Steps for implementing the program and integrating it into a total cropping system are summarized.

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Introduction

Soybean production in Illinois has climbed steadily from 1.4 million bushels in 1924 to almost 369 million bushels in 1979. This increase resulted from a threefold improvement in yields and an 85-fold expansion in the acreage planted. Today, soybean is a mainstay of Illinois's economy, accounting for a third of the total cash farm income.

With roughly 40 percent of the farmland planted to soybean, the crop may be found over much of the state's 56,400 square miles (Fig. 1). A relatively long state (382 miles), Illinois covers a wide range of latitudes with noticeable differences in climate, soil type, topography, and natural plant cover. Soybean growing conditions vary accordingly from one part of the state to the next.

Fig. 1. Soybean production in Illinois. One dot equals 200,000 bushels.

The nature and severity of soybean insect problems also vary from region to region. As a whole, however, these problems are less severe than in other growing regions of the world. During a normal year in Illinois the soybean acreage treated against insects is only 0.5 to 1 percent of the total soybean acreage. On occasion, however, localized outbreaks of certain pests have led to widespread spraying with insecticides.

For sound ecological and economic reasons, insecticide use on soybean should be restricted to situations where treatment is absolutely necessary. Modern pesticides are a powerful weapon at the disposal of soybean growers, but maximum benefit is derived only from judicious use. Misuse may result in many undesirable side effects.

How can we best estimate if and when to spray a soybean field? The most reasonable course to follow is to adopt management practices derived from a knowledge of soybean pests and their effect on the crop. These practices form the basis of an integrated pest management program for controlling pests in Illinois.

> Integrated pest management (IPM) is the selection of practices that will assure favorable economic, environmental, and social consequences through the use of appropriate cultural, biological, and chemical control measures.

We have organized these guidelines to help growers, Extension advisers, pesticide dealers and applicators, pest management consultants, and farm managers in developing effective pest management practices. Such practices should result in economic benefits to farmers without upsetting the ecological balance that seems to exist in Illinois soybean fields.

The guidelines are divided into eight major sections:

- Description of soybean growth stages.
- Symptoms of plant injury and the related insect pests. Three keys appear in this section as an aid to identification.
- Identification of insect pests and information about their biology. Four keys, drawings, and many color photographs are presented in this section.
- Discussion of parasites, predators, and diseases that provide natural control of soybean insect pests.
- Maps and a chart indicating areas at risk for outbreaks of major pests.
- Components of the pest management program, including scouting methods, forecasting, control tactics, and decision charts for selecting appropriate control actions.
- Personnel who help implement the pest management program.
- Eleven steps for implemention and a planning calendar.

These guidelines should be used in conjunction with other information provided by the Illinois Cooperative Extension Service. In particular, insecticide use should be based on recommendations in Circular 899, "Insect Pest Management Guide: Field and Forage Crops," which is revised annually by Extension entomologists.

Insect Injury and Plant Development

Many harmful as well as beneficial species of insects and mites inhabit soybean fields. Some species that are adapted to feed on particular parts of the soybean plant may cause considerable damage (Fig. 2). Other species prey on the plant eaters and are therefore beneficial because they help keep pest populations under control.

The nature of the damage caused by plant-eating species depends on the part attacked and when attack occurs during the plant's growth cycle. Insects can injure soybean by defoliating the plant, sucking sap from leaves and stems, debranching or breaking entire plants as a result of stem feeding, destroying blossoms, boring or piercing the pods, and destroying seeds. Other less evident types of injury result from feeding on roots and nodules; piercing and sucking green seeds, thereby causing seed malformation and consequent reduction of quality; transmitting disease organisms; and injecting toxins.

Fortunately, not all pest species appear in a field at the same time. By studying the dynamics of their life cycle, you will see that each species appears only during particular phases of crop development (Fig. 3).

The sections that follow describe the developmental stages of the crop, how it grows in Illinois, and the types of injury affecting different parts of the plant at each stage of its growth. First, however, we must introduce some concepts related to the economics of pest management.

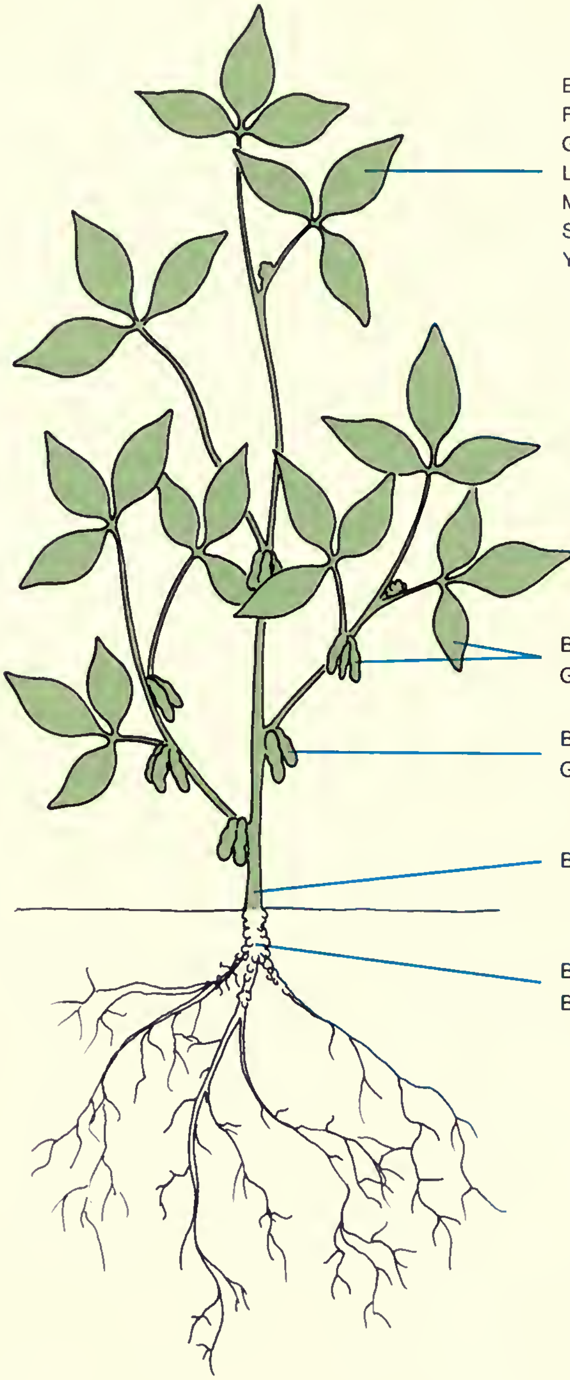


Fig. 2. Insect pests that are adapted to feed on particular parts of the soybean plant.

Economics of Pest Management

An insect or mite species becomes a pest when the amount of crop loss it causes equals or exceeds the cost of preventing the loss. This relationship between the amount of damage prevented and the cost of prevention is an expression of the economic injury level.

Economic injury level is the level at which a pest population is capable of causing enough injury to justify the cost of applying an insecticide to prevent the injury.

In practice, however, the rate of population increase should be estimated before the pest reaches the economic injury level to allow time for applying the insecticide. The turning point is usually defined for soybean defoliators as the economic damage threshold.

Economic damage threshold is the combination of certain damage and population levels at which chemical controls should be applied to prevent the pest population from reaching the economic injury level.

Economic injury levels and damage thresholds depend on the stage of plant development and whether the pests are defoliators or pod feeders. Thresholds have been established for only a few soybean pest species. The known thresholds will be presented in some detail in the section on "Injury to Soybean."

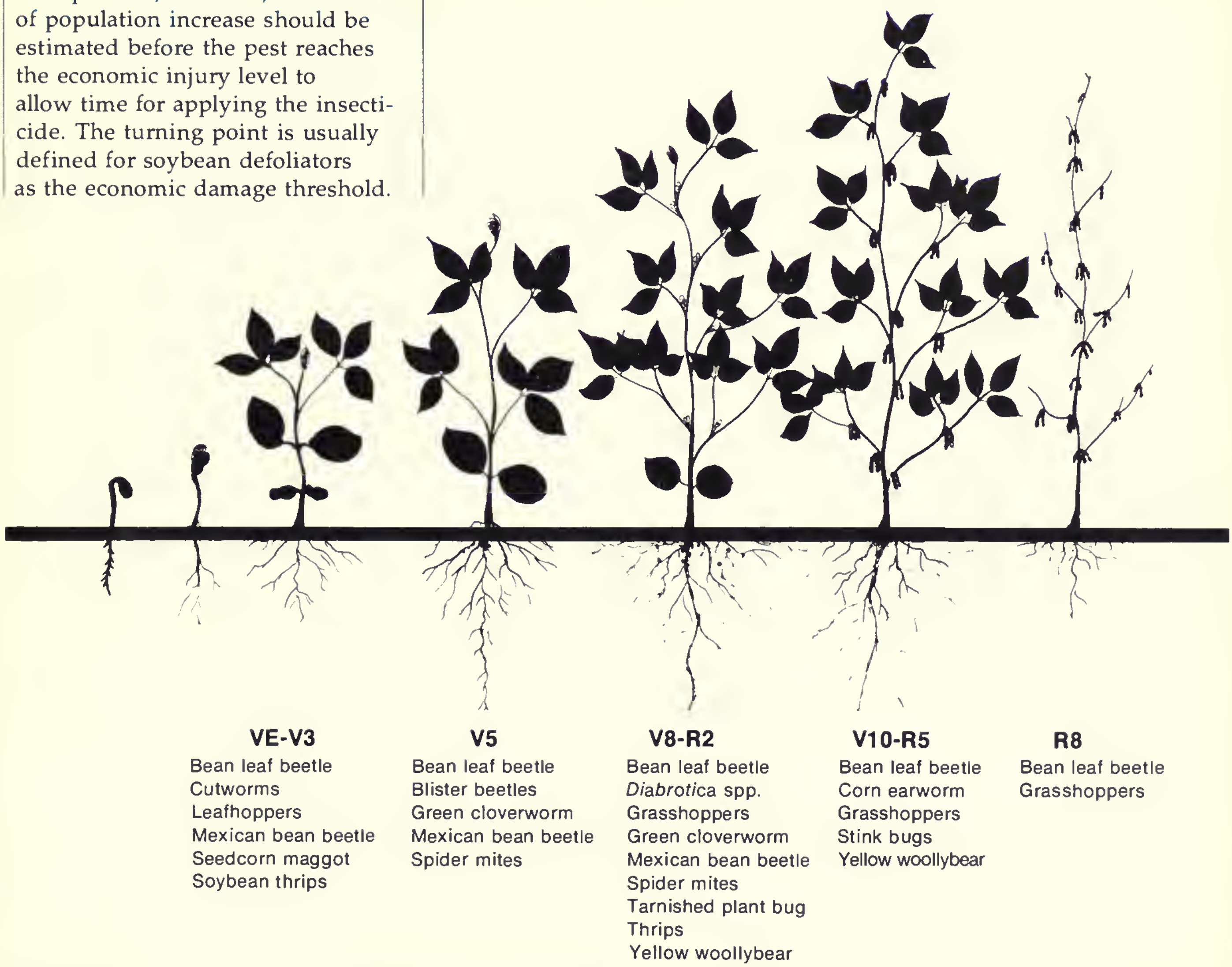


Fig. 3. At each growth stage the crop is attacked by a different complex of insect pests. Stages of growth: VE-V3 = seedling; V5 = early vegetative growth; R2 = full bloom; R5 = beginning seed; R8 = full maturity.

Soybean Growth

A plant's susceptibility to injury varies from the prebloom through the bloom, pod-set, and pod-fill stages. A numbering system has been devised to identify these different stages of plant growth. The system is described here and will be referred to farther on in these guidelines. We have also included a description of other plant and crop characteristics that have a direct bearing on pest control in soybean.

Growth Stages

Nodes are the points at which leaf petioles or branches are attached to the main stem (Fig. 4). The number of nodes is used to describe the vegetative stages, which are designated by the letter *V*. The reproductive stages — bloom, pod set, and pod fill — are designated by the letter *R*.

Emerging seedlings are at stage VE, and seedlings with open cotyledons are at stage VC. After the VC stage, the appearance of one unifoliolate node signals stage V1, followed by a second node with an open trifoliolate leaf at stage V2, a third node at V3, and so on. The reproductive stages go from R1 to R8, that is, from early flowering through pod maturity (Table 1). In Figure 3 a series of growth stages is identified according to the V-R system. (For a detailed description of the system, see Iowa Cooperative Extension Service Special Report No. 80, 1977.)

Table 1. Growth Stages of Soybean

Stages	Stage name	Description
Vegetative		
VE	Emergence	Cotyledons above the soil surface
VC	Cotyledon	Unifoliolate leaves unrolled enough so that leaf edges are not touching
V1	First-node	Fully developed leaves at unifoliolate nodes
V2	Second-node	Fully developed trifoliolate leaf at node above unifoliolate nodes
V3	Third-node	Three nodes on main stem with fully developed leaves beginning with unifoliolate nodes
V(n)	nth-node	n number of nodes on main stem with fully developed leaves beginning with unifoliolate nodes; n can be any number, beginning with 1 for first-node stage (V1)
Reproductive[a]		
R1	Beginning bloom	One open flower at any node on main stem
R2	Full bloom	Open flower at one of two uppermost nodes on main stem with fully developed leaf
R3	Beginning pod	Pod 5 mm long at one of four uppermost nodes on main stem with fully developed leaf
R4	Full pod	Pod 2 cm long at one of four uppermost nodes on main stem with fully developed leaf
R5	Beginning seed	Seed 3 mm long in pod at one of four uppermost nodes on main stem with fully developed leaf
R6	Full seed	Pod containing a green seed that fills pod cavity at one of four uppermost nodes on main stem with fully developed leaf
R7	Beginning maturity	One normal pod with mature pod color on main stem
R8	Full maturity	Ninety-five percent of pods with mature pod color; five to ten days of drying weather usually required after R8 before soybeans dry to less than 15 percent moisture

[a] The designation for a plant at a reproductive stage should include both the V and the R stages. For example, at full bloom a plant with 11 fully developed trifoliolates above the unifoliolate nodes would be at stage V12R2 because the unifoliolate nodes are counted as one.

Adapted from: Iowa Cooperative Extension Service Special Report No. 80, 1977.

Stand Establishment

Effective pest management starts with seed of superior quality. Healthy seed planted at the appropriate depth in a well prepared seedbed according to agronomic recommendations is the best guarantee for a good stand. Anything that delays germination, such as prolonged, cool soil temperature after sowing, increases the chance that insects and diseases will attack the germinating seeds or seedlings and thereby reduce the stand. Rapidly emerging plants are less susceptible to attack from diseases and soil-dwelling insects. Of course, growers cannot control soil moisture and temperature, but the factors they can control should be carefully managed to minimize pest problems.

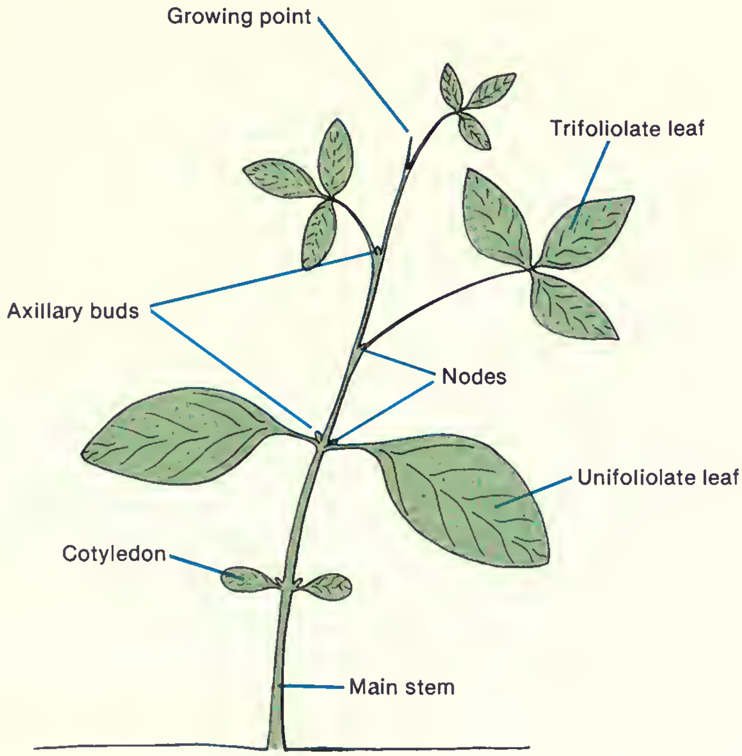


Fig. 4. Soybean seedling.

Crop Phenology in Illinois

Phenology is the relationship between events in the crop's cycle and seasonal, climatic factors. To ensure rapid germination and emergence, planting is customarily done after the risk of frost is past and when soil temperature and moisture are adequate. For single-cropped soybean in Illinois, planting usually starts after May 10 and may extend to the end of June. On the average, though, about half of the crop is in the ground by May 25 (Fig. 5).

Between July 10 and 20 half of the crop is in full bloom (stage R2), and pods begin to appear. By the end of the month half of the state acreage is in the pod-setting stages (R3 and R4). Harvesting may start as early as the first week of September. Normally it is at the halfway mark by September 30 and completed by the end of October (Fig. 5).

In double cropping, soybean is planted sometime after June 20 as soon as small grains are harvested. Consequently, all stages of growth are somewhat delayed. Double cropping has special pest problems, but we are just beginning to understand its effect on pests.

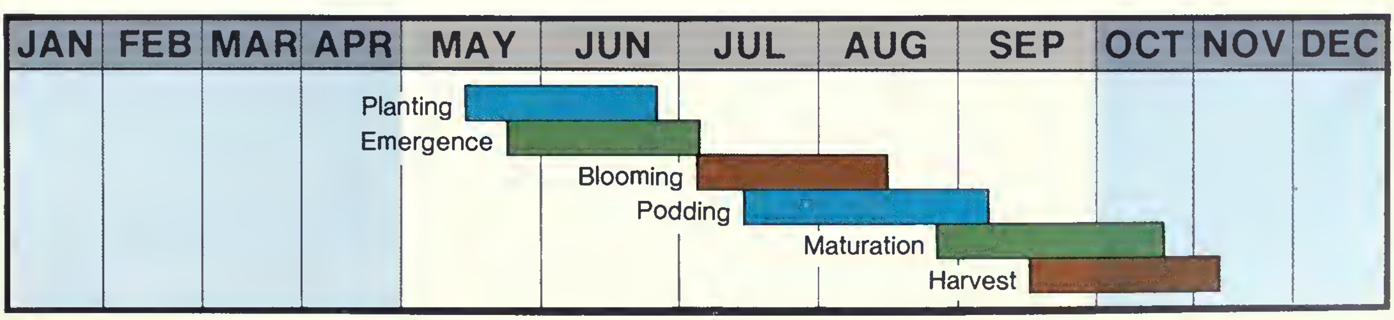


Fig. 5. Crop phenology in Illinois.

If you visit a soybean field every week to ten days, you'll see that different types of pests appear as the plants change from one growth stage to the next. Figure 3 lists the pests likely to be present at various times in the crop cycle. Each pest may injure one or more parts of the plant, but seldom the entire plant. Figure 2 lists some pests and the plant parts preferentially attacked.

Injury to Germinating Seeds and Seedlings

Bean leaf beetle adults
Cutworms
Mexican bean beetle
Potato leafhopper
Seedcorn maggot
Soybean thrips

Nature of injury

Early season pests attack germinating seeds in the soil or seedlings immediately after emergence. In either case, the result is a reduced stand.

Seedcorn maggots feed on cotyledons and embryos while they are still below ground. **Potato leafhoppers, soybean thrips,** and adults of **bean leaf beetles** and **Mexican bean beetles** are often found on seedlings shortly after emergence.

Potato leafhoppers have piercing mouthparts with which they suck the sap. Although populations may be abundant, they seldom cause economic damage to most of the common commercial varieties. **Soybean thrips** have rasping mouthparts. As a result of their feeding, the leaflets take on a silvery appearance, injured tissue turns yellow, and the leaflets finally die.

Bean leaf beetles, Mexican bean beetles, and **cutworms** have chewing mouthparts that can injure cotyledons, leaves, and stems. **Bean leaf beetles** cut small round holes in leaves (Fig. 6) or may sever the hypocotyl arch, thereby killing the plant. **Mexican bean beetles** produce lacelike damage to the leaves. Some **cutworms** gnaw the seedling off just above the surface of the soil (Fig. 7). Although they may not eat much of the plant, they do eat enough to make it fall over.

Fig. 6. Injury to seedlings by bean leaf beetles.

Fig. 7. Seedlings destroyed by black cutworms.

Economic damage thresholds

Except for the bean leaf beetle, no thresholds have been established for insects that feed on germinating seeds and seedlings. The main effect of this group of insects is reduction of the stand.

To produce good plant stands, growers should maintain the optimal stands that are currently recommended:

Row width, inches	Plants per foot of row
40	10 to 12
30	6 to 8
20	4 to 6
10	3 to 4

Reduction of plant density may result in some yield loss (Table 2). But insecticide treatments are justified only if the stand is reduced to less than two-thirds of the rates indicated above, or if irregular open spaces begin to show in the stand. If a field has a good stand despite severe initial attack, plants will recover under normal growing conditions with no observable effect on yield (Table 3).

The capacity of plants to recover from damage inflicted this early in development is remarkable. In most cases, plants can tolerate severe injury at the seedling stage if other growing conditions, particularly moisture and temperature, are adequate.

Injury to Roots and Nodules

Bean leaf beetle larvae
Clover root curculio larvae
Grape colaspis larvae
Rivellia bean fly
White grubs
Wireworms

Nature of injury

This group includes pests that inhabit the soil and feed on subterranean plant parts during germination. Later as the plants grow, these pests destroy roots and the nitrogen-fixing bacterial nodules (Fig. 8).

The effect of insect feeding on soybean roots and nodules is not well known. **White grubs** can be very damaging in certain areas of the state. According to the findings from experiments using garden beans, the feeding of **bean leaf beetle larvae** on roots and nodules can affect yields. Root feeding may also lead to premature lodging.

Economic damage thresholds

No thresholds have been established for pests that feed on roots and nodules. Under normal growing conditions in Illinois, plants usually compensate for moderate levels of root injury or reduction in plant stand. The failure of seedlings to emerge or yellowing after emergence may indicate damage by underground pests. Some replanting may occasionally be necessary.

Fig. 8. Injury to nodules by bean leaf beetle larvae.

Table 2. Ability of Soybean to Compensate for Reduction of Plant Density, Urbana, Illinois

Stand within rows 20 feet long	Percent of original stand	Yield, bu/A
Six plants per foot of row	100	50
Three 40-inch gaps	50	41
Five 24-inch gaps	50	44
Three plants per foot of row	50	50
Four plants per foot of row	66	51
Five plants per foot of row	80	50

Adapted from: *Illinois Agronomy Handbook 1979-80*. Circular 1165. University of Illinois, College of Agriculture.

Table 3. Yield Reduction After Injury to Soybean Cotyledons and Leaves Early in Season

Type of injury	Yield reduction, percent
1 cotyledon removed after seedling emergence	0
2 cotyledons removed after seedling emergence	1.0
2 cotyledons removed with first unifoliolate expanded	0
2 unifoliolates removed after expansion	2.8
2 unifoliolates and 2 cotyledons removed after unifoliolate expansion	7.3
Seedling cut below unifoliolates after expansion	16.1

Adapted from: *Crop Science* 6:25-27, 1966.

Injury to Foliage

Frequently damaging
- Bean leaf beetle
- Green cloverworm
- Grasshoppers
- Twospotted spider mite

Occasionally damaging
- Blister beetles
- Japanese beetle
- Yellow woollybear

Rarely damaging
- Alfalfa caterpillar
- Clover root curculio
- Corn earworm
- Legume leafminer
- Mexican bean beetle
- Painted lady
- Potato leafhopper
- Soybean thrips
- Webworms
- Whiteflies

Fig. 10. Foliage injury by green cloverworm.

Fig. 11. Foliage injury by bean leaf beetle.

Fig. 12. Foliage injury by Mexican bean beetle larva.

Nature of injury

Most of the foliage-feeding species listed here have chewing mouthparts that can cause considerable injury (Fig. 9). A single **green cloverworm,** for example, can cut about 18.6 square inches of leaf area during its larval period. The method of feeding and the feeding patterns found on a plant are characteristic of each species. Thus the **green cloverworm** makes indentations along the margins or cuts large holes in the leaf blade. The **bean leaf beetle** cuts small holes. The **Mexican bean beetle** crushes the leaf tissues, which dry out and form a lacy network resembling windrows (Fig. 10, 11, 12). Wind and hail magnify the damage from chewing insects by causing the leaf blades to tear between the larger veins.

Thrips, leafhoppers, and **mites** have either rasping or sucking mouthparts. They do not remove pieces of leaves, but the feeding areas become chlorotic (yellowish), dry out, and turn brown (Fig. 13). Intense sucking of **mites** or **thrips** in particular may cause leaves to become dry and fall off.

Regardless of the species, the end results of these different types of foliage feeding are very similar. The total leaf area capable of photosynthesizing is reduced, and consequently the plant lacks enough photosynthate for growth and seed production. If insect populations are very large, plants may be completely stripped of leaves.

Fig. 9. Woollybear larva feeding on soybean leaf.

Economic damage thresholds

Soybean can tolerate considerable defoliation without yield reduction. Tolerance varies with the stage of plant growth, overall plant vigor, and the adequacy of growing conditions such as moisture, temperature, and soil fertility. The relationship between defoliation at four growth stages and the probable yield reduction is shown graphically in Figure 14. The four stages are: vegetative growth (VC to beginning of R1), blossom development (R1 to R2), pod development (R3 to R5), and seed maturation (R6 to R8).

While the plants are still growing and producing new leaves, and again after the seeds are completely filled, soybean can tolerate considerable defoliation without yield loss. But during the early part of the reproductive stage, the plants become increasingly sensitive to defoliation. They are most sensitive during the period of pod development. Even at this stage (R4 to R6), however, soybean plants can normally lose 20 percent of their leaf area before any effect on yield occurs.

Correct estimates of defoliation and the pest population responsible are essential to establishing the economic damage thresholds for foliage-feeding insects. Methods for estimating defoliation and measuring pest populations are discussed in the section on the pest management program. The thresholds currently available for soybean defoliators are summarized in Table 4.

Fig. 13. Typical foliage injury by spider mites.

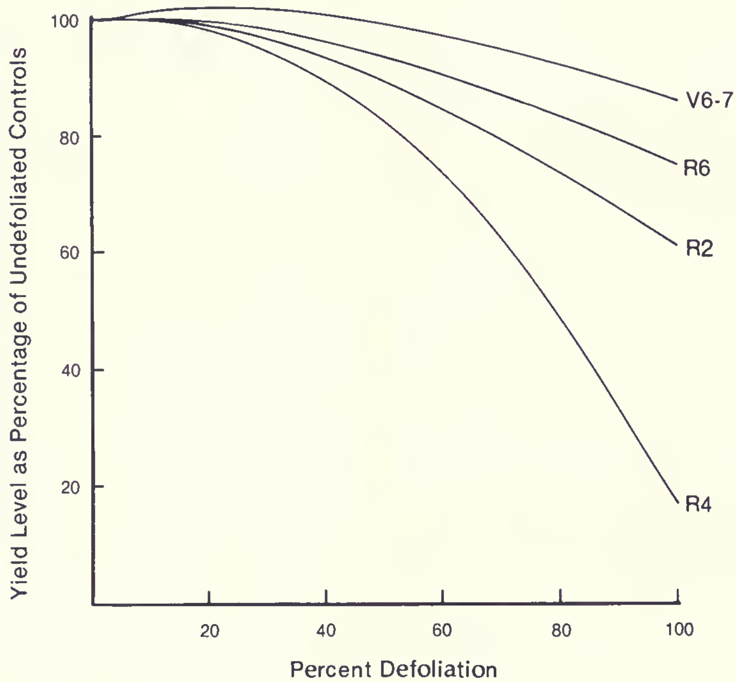


Fig. 14. Relationship between defoliation and yield reduction at four stages of plant growth.

Table 4. Economic Damage Threshold for Defoliators with Chewing Mouthparts — Plants Within Pod-Set and Pod-Fill Stages (R3 to R6)

Species	Thresholds
Bean leaf beetle	16 beetles per foot of row, 20 percent defoliation
Green cloverworm	8 to 12 worms (more than ½ inch long) per foot of row, 20 percent defoliation
Grasshoppers	4 to 6 adults and large nymphs per foot of row, 20 percent defoliation

Injury to Blossoms

Corn rootworm beetles
Tarnished plant bug
Thrips

A soybean plant normally sheds 50 to 70 percent of the flowers that are formed, probably for physiological reasons. The contribution of insect feeding to the amount of shedding is unknown.

Nature of injury

Frequently found on soybean, the **flower thrips** seem to feed mostly on pollen. Although the effect of pollen feeding on pod set has not been determined, some soybean breeders have observed that thrips seem to reduce the success of artificial pollination.

Adults of the **tarnished plant bug** are often found on soybean in the Midwest after alfalfa has been cut or other preferred hosts have been eliminated. In cage tests, the prolonged feeding of this bug on soybean buds or blossoms reduced the number of pods per node and the number of seeds per pod, but the average weight of seeds was not affected. In open soybean fields, the bug's feeding and the effect on yields have not yet been demonstrated.

Economic damage thresholds

No thresholds have been established for pests feeding on blossoms.

Injury to Pods

Bean leaf beetle adults
Brown stink bug
Corn earworm
Green stink bug
Grasshoppers
Limabean pod borer

At the pod-set and pod-fill stages of crop growth (R3 to R5) the direct feeding of insects on pods may destroy seeds and cause whole pods to be shed, thereby reducing yields. The feeding of **stink bugs** and **bean leaf beetles** can also affect seed quality. In certain areas of the country one of the most serious pests of soybean is the **corn earworm,** which can destroy a large number of pods. Although present on corn in Illinois, the corn earworm has not yet been reported attacking soybean.

Nature of injury

Equipped with chewing mouthparts, insects such as **grasshoppers, caterpillars,** and **beetles** chew the outer layer (pericarp) of pods and destroy the seeds. Pod and seed destruction can be quite extensive (Fig. 15). The small larva of the **limabean pod borer,** which is rarely found in Illinois, bores into the pod and feeds on the seeds.

Stink bugs are among the most damaging pod feeders. Both nymphs and adults obtain food by puncturing stems, foliage, flowers, and particularly seeds through the pod walls. Damage results from the loss of plant juices, injection of digestive enzymes, and the entrance of disease organisms through the wound. Stink bugs may also transmit the fungus that causes yeast spot disease. When the attack occurs early, pod development is retarded, and

Fig. 15. Pod injury by grasshoppers.

pods and seeds are discolored and deformed (Fig. 16). Later injury results mostly in discoloration around the puncture site. A decline in seed quality is due to a change in oil content, more rapid deterioration during storage, and a greater incidence of disease. If the embryo is punctured, seeds may not germinate. The grain must therefore be downgraded for industrial use.

Late in the season **bean leaf beetle adults** may chew on pods after the leaves become too old. Scars on the pods (Fig. 17) open the way to spores of various fungal diseases that are normally blocked by the pericarp. Mild infection results in seed staining; severe infection results in total seed contamination (Fig. 18, 19).

Economic damage thresholds

Pod feeders destroy the grain itself late in the season when plants have little time to recover. Therefore, it is important to keep the population of these insects at a low level. Current economic thresholds are shown in Table 5.

Fig. 17. Pod scars caused by bean leaf beetles.

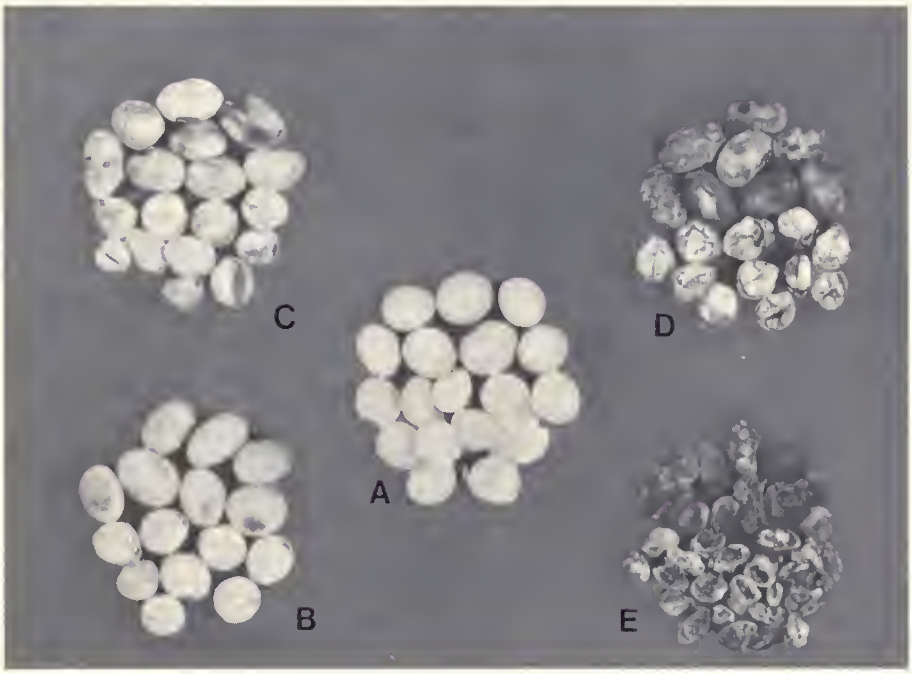


Fig. 16. Classes of seed injury by stink bugs: A, none; B, light; C, medium; D, heavy; E, severe.

Fig. 18. Opened pod, showing scars and stained seed.

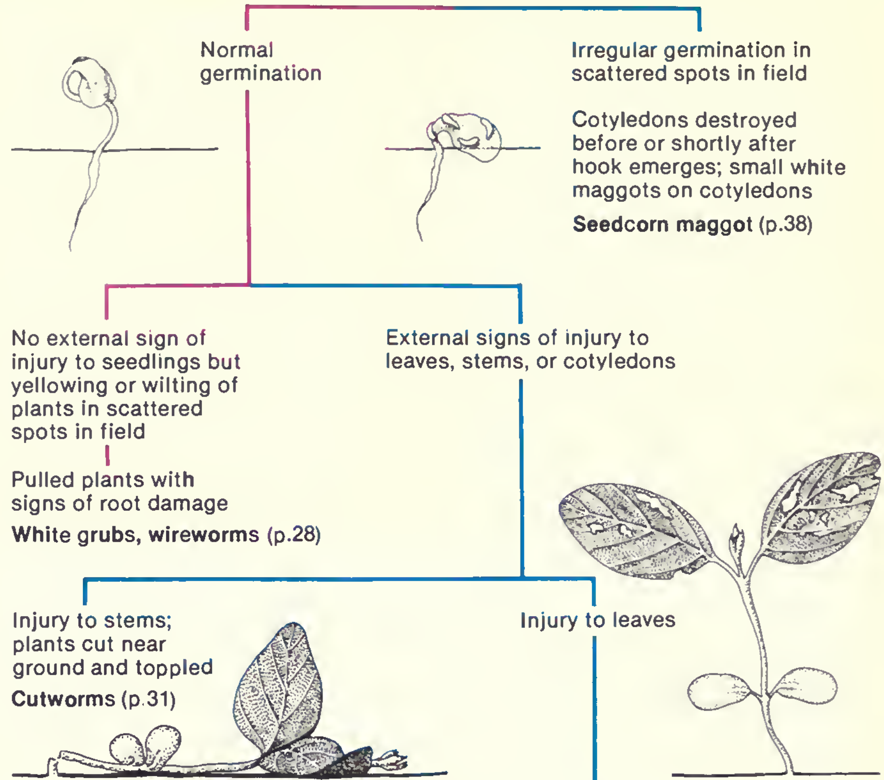
Fig. 19. Moldy seed resulting from pod injury by bean leaf beetles.

Table 5. Economic Damage Thresholds for Pod-Feeding Insects

Species	Thresholds
Corn earworm	3 worms per foot of row
Stink bugs	1 stink bug (more than ¼ inch in diameter) per foot of row
Bean leaf beetle	8 beetles per foot of row, 8 percent injured pods
Grasshoppers	Grasshoppers active, 8 percent pod feeding

Identification of Symptoms

Illustrated keys are provided in Figures 20 A, B, and C to help identify some of the most common types of soybean injury caused by insects. The keys are divided into symptoms found early in the season (VC to V6), during mid-season (V7 to R4), and late in the season (R5 to R8). In some cases you may be unable to clearly attribute the type of injury to a particular species, but in any event, try to collect the insects to make a positive association between the injury and its cause.



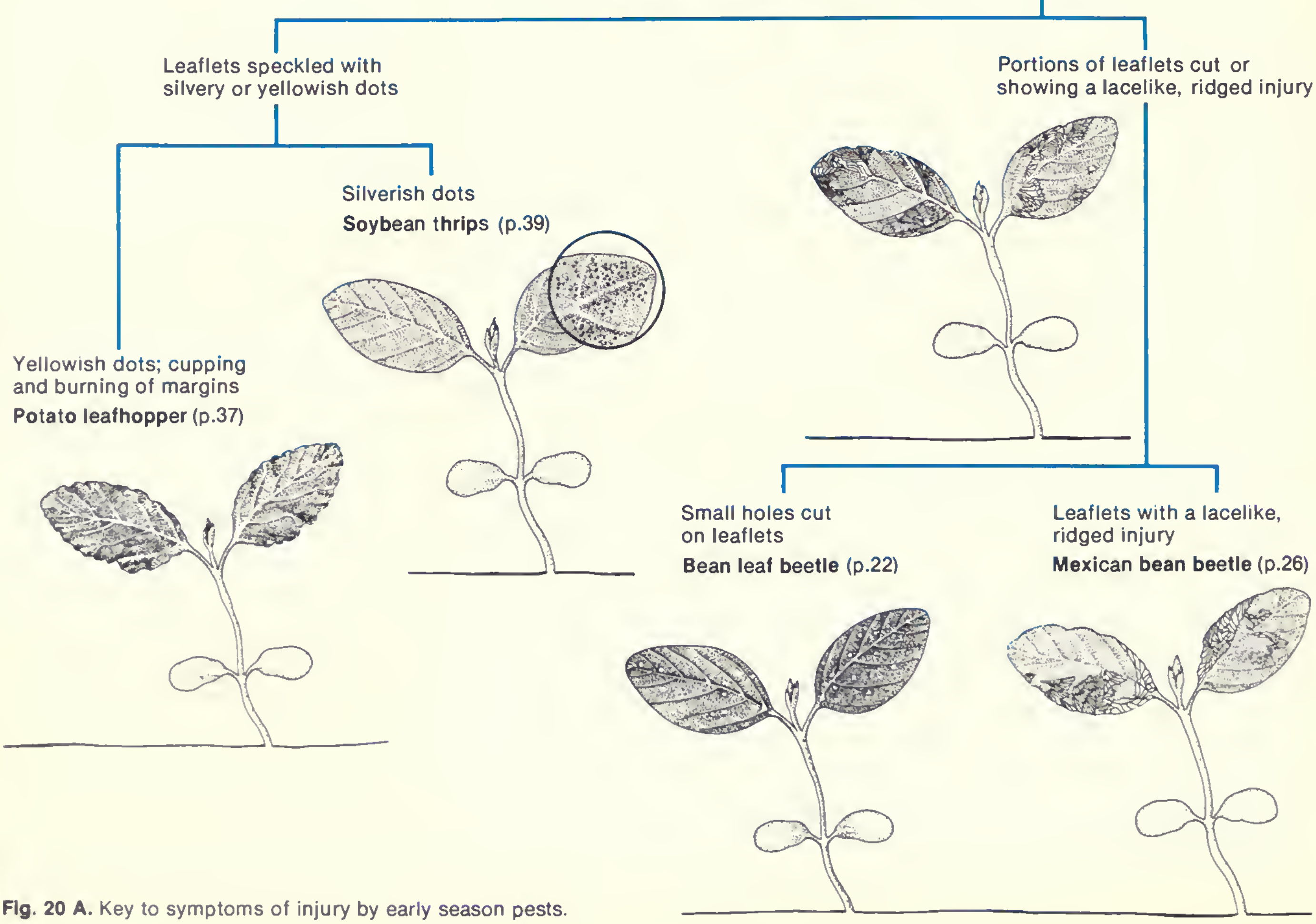


Fig. 20 A. Key to symptoms of injury by early season pests.

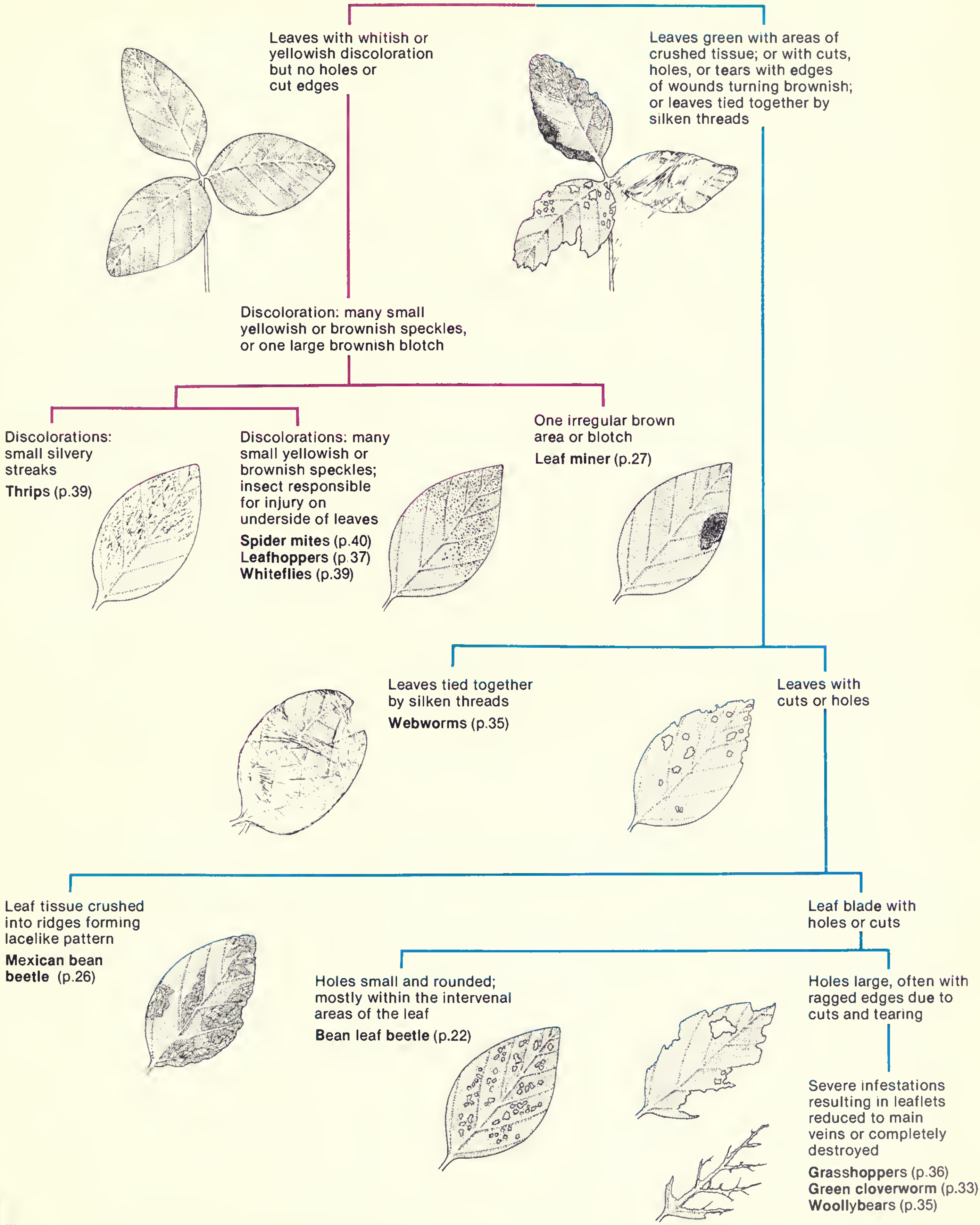
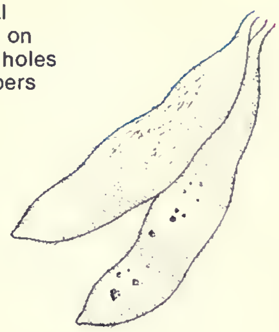


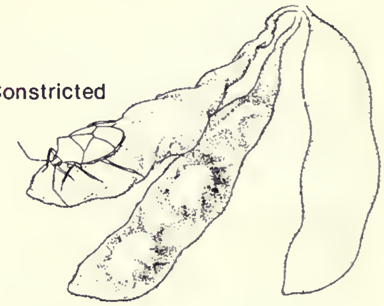
Fig. 20 B. Key to symptoms of injury by mid-season pests.

Pods formed normally but with external signs of feeding on pericarp or with holes into seed chambers



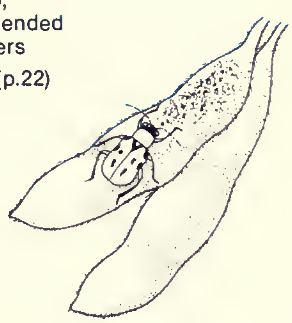
Pods not formed normally; one or more seeds aborted or pods completely collapsed

Stink bugs (p.29)



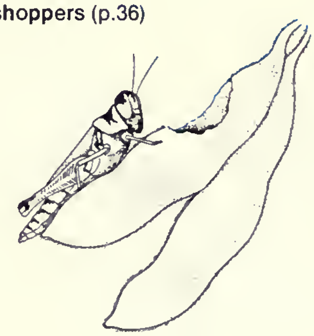
Pods with numerous scars on pericarp; injury seldom extended into seed chambers

Bean leaf beetle (p.22)



Seed destroyed by insects feeding externally

Grasshoppers (p.36)



Pods with holes; seeds destroyed by insects feeding externally or internally

Corn earworm (p.32)
Limabean pod borer

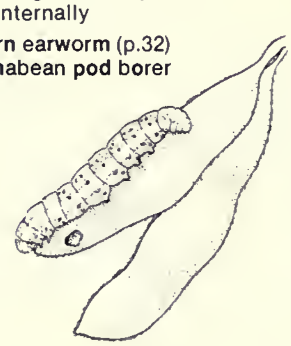


Fig. 20 C. Key to symptoms of injury by late season pests.

Identification and Biology of Insects

Correct identification of insect pests and their natural enemies is essential, because control recommendations depend on the species present. Illustrated keys to the most common insect pests found on soybean are provided in Figures 22 A, B, C, and D; mites are not included.

A general key (A) separates the pests that feed below ground level on roots and nodules and those that feed above ground level on foliage, stems, flowers, or pods. As you follow this general key, you will be directed to three identification keys: one for the belowground feeders (B) and two for the aboveground feeders (C and D). The keys for the aboveground feeders help identify pests that are normally observed at the adult stage and that usually have wings, and pests that are usually found at the larval stage. The anatomical parts used in these identifications are shown in Figure 21. A brief description of the life history, habits, and seasonal history in Illinois follows the keys.

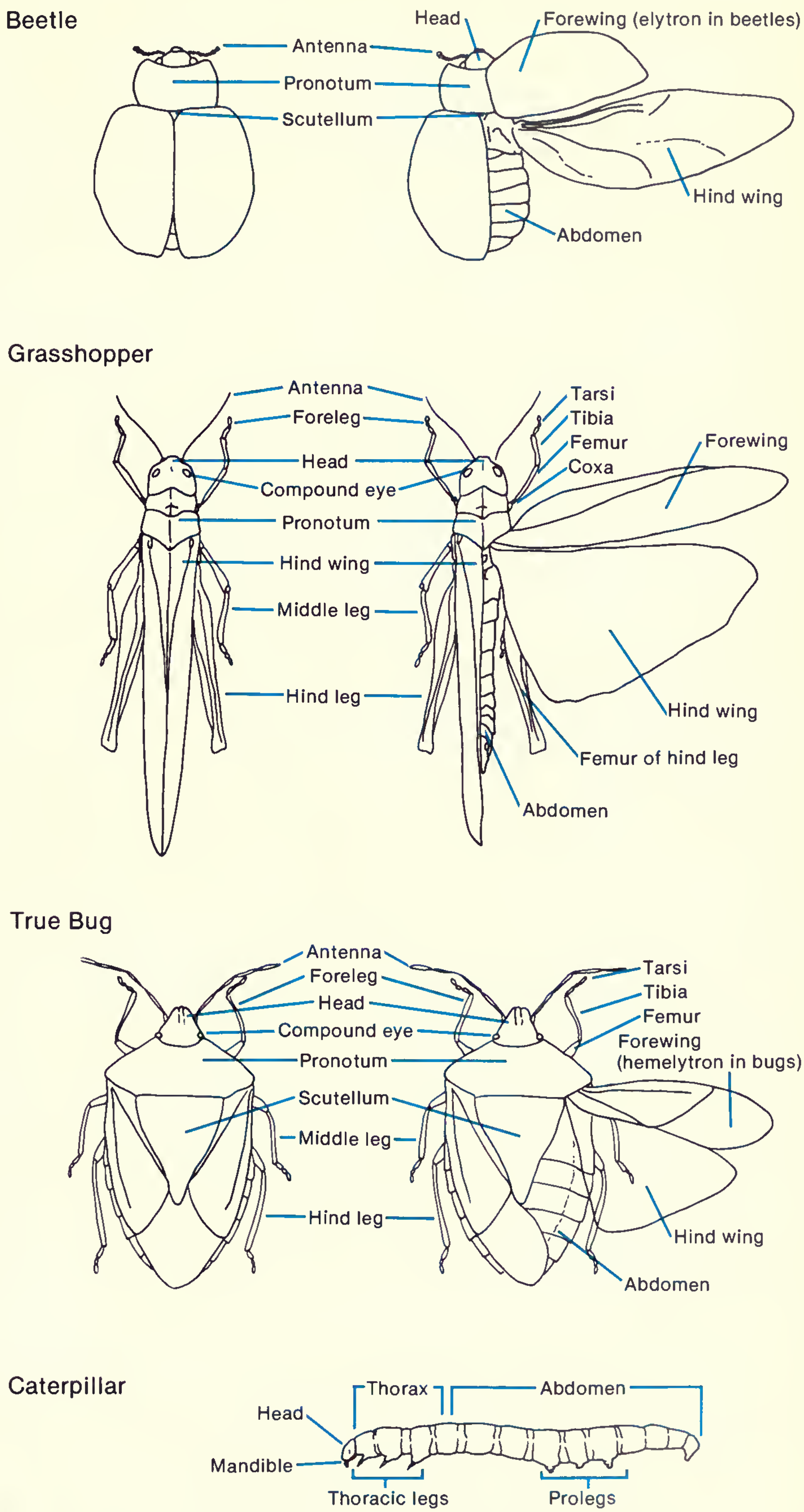


Fig. 21. Diagrams showing the anatomical parts used to identify insect pests.

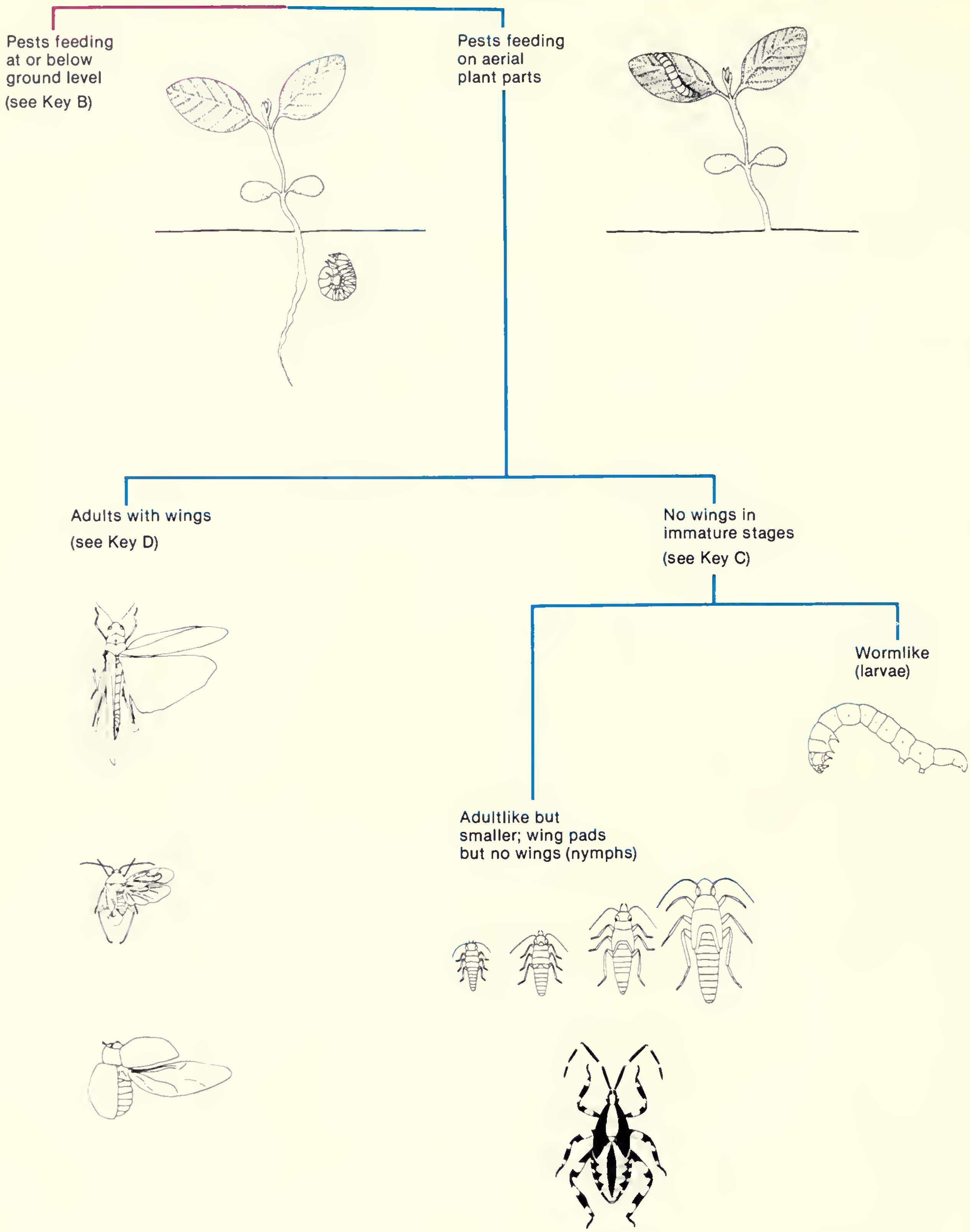


Fig. 22 A. General key to soybean pests.

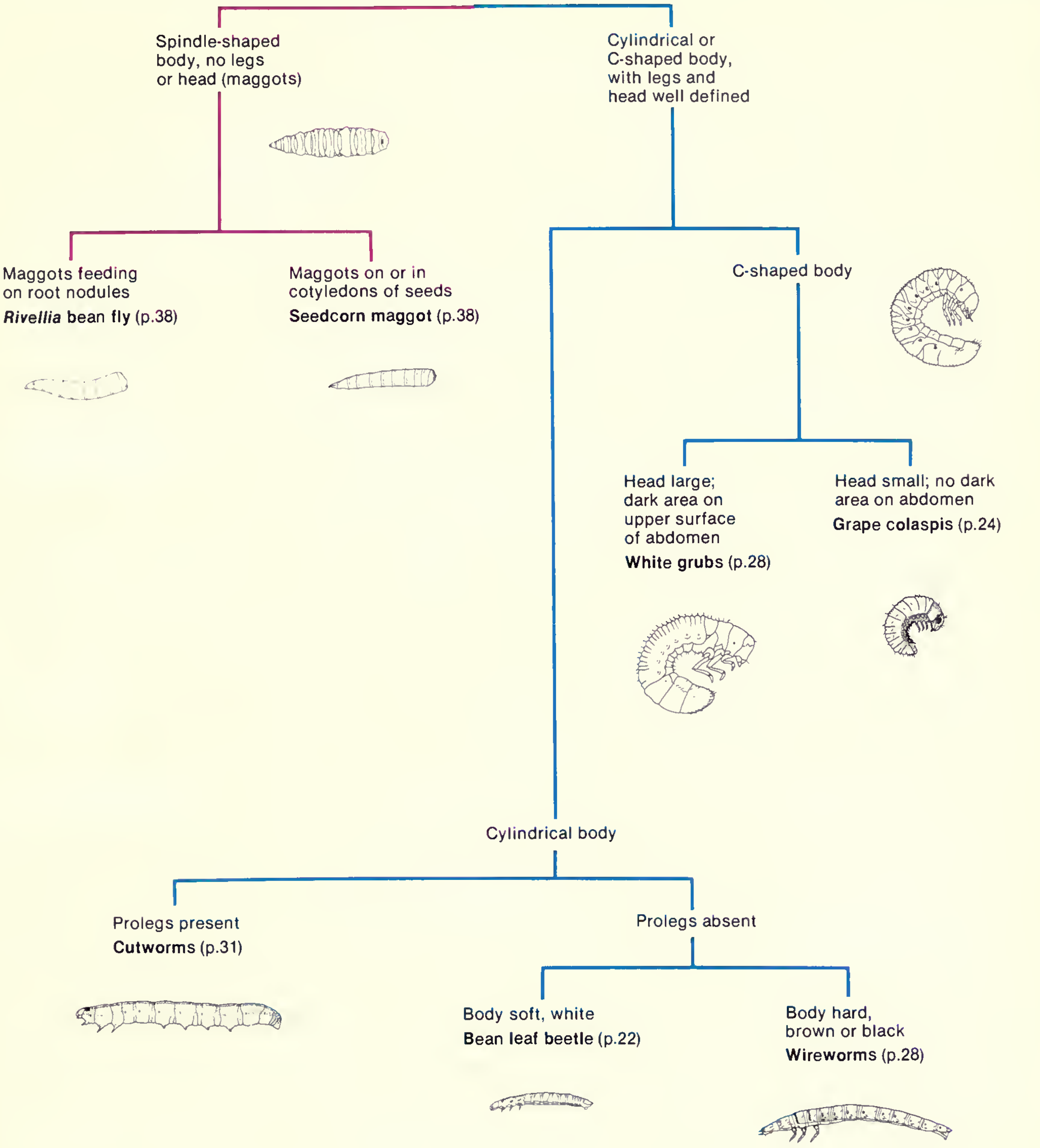


Fig. 22 B. Key to pests at or below ground level.

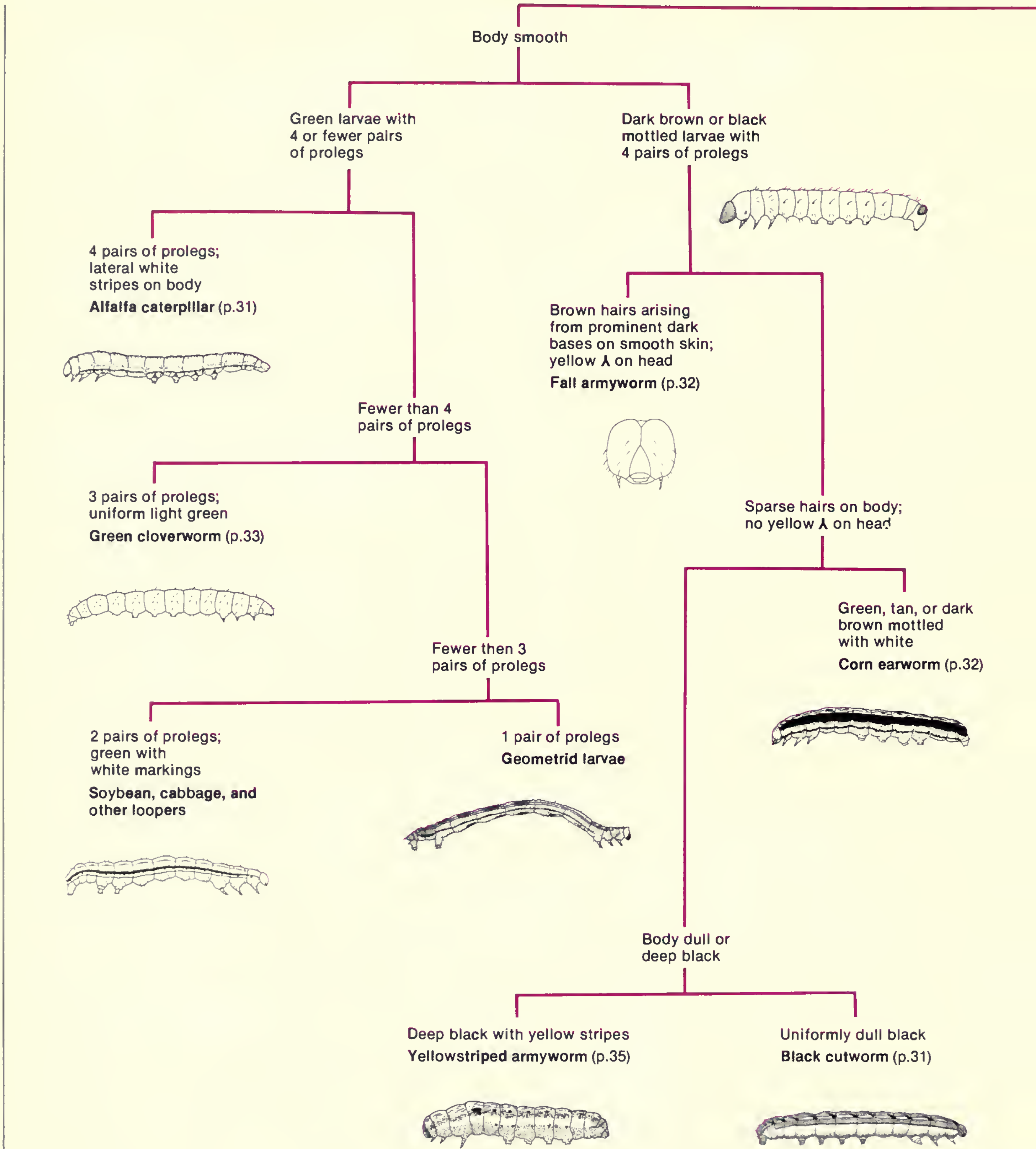


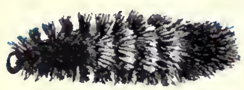
Fig. 22 C. Key to immature pests above ground level.

Body with long thin hairs or short branched spines

Body covered with long hairs; white, tan, or dark brown

Larvae white to dark brown; free-living

Woollybear (p.35)



Larvae inside nests made of leaves tied with silk

Webworms (p.35)

Body totally or partly covered with branched spines

Completely covered with branched spines; no prolegs; compact

Mexican bean beetle (p.26)

Some branched spines; 4 pairs of prolegs; elongated

Painted lady larvae (p.34)

Chewing mouthparts; head not elongated into beak

Large hind legs for jumping

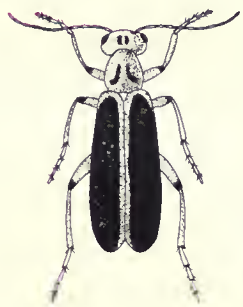
Hind legs not enlarged

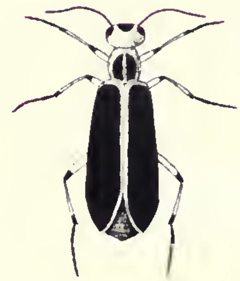
Head wider than thorax; legs long and slender, not for jumping; insect longer than ½"

Blister beetles (p.23)

Hind legs green to brown; insect 1" to 2" long

Differential grasshopper (p.36)

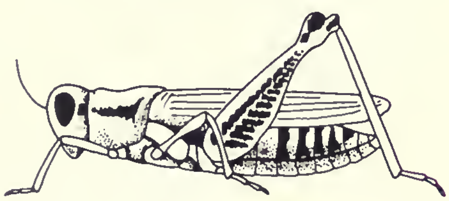




Head narrower than thorax; legs shorter and not slender; insect less than ½"

Inside of hind legs reddish; insect 1" long

Redlegged grasshopper (p.36)



Body compact with no visible constrictions; round or oval

Round, dark yellow to tan; antennae visible from above

Oval, metallic; antennae not visible from above

Japanese beetle (p.25)

Dark yellow or bronze with black spots; wing covers smooth

Mexican bean beetle (p.26)

Tan, no black spots; wing covers with ridges

Grape colaspis (p.24)

Fig. 22 D. Key to adult pests above ground level.

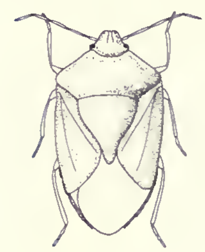
- Piercing and sucking mouthparts; head elongated into beak

  - Less than ¼"
    - Narrow wings with fringe of long hairs
      Thrips (p.39)

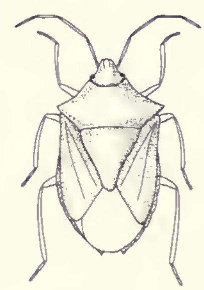
    - Wings not narrow; no fringe of hair
      - Oval body covered with fine white powder
        Whiteflies (p.39)

      - Body not oval or covered with powder
        Leafhoppers (p.37)

  - Longer than ¼"
    - Bright green shield-shaped bug
      Green stink bug (p.29)



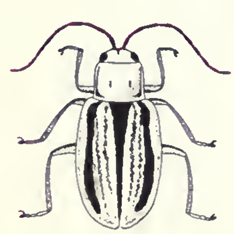
    - Brown shield-shaped or elongated bug
      - Shield-shaped
        Brown stink bug (p.29)



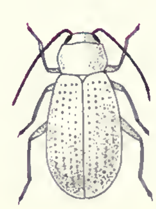
      - Elongated body
        Tarnished plant bug (p.30)

- Body elongated, clearly constricted between head, thorax, and abdomen
  - Head with no snout; color variable
    - Wing covers smooth; various colors; may have black spots or stripes
      - Small black triangle at base of wing covers; yellow to dark red with or without 4 large black dots on wing covers
        Bean leaf beetle (p.22)

      - Black triangle absent; color variable
        - Black and yellow striped
          Western corn rootworm (p.26)

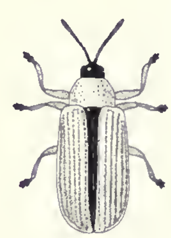


        - Plain green or green with 11 black spots
          - Plain green
            Northern corn rootworm (p.26)

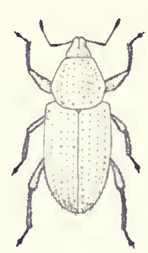


          - Green with 11 black spots
            Southern corn rootworm (p.26)

    - Wing cover with ridges, dark red or orange, often with black stripe down center
      Odontota **leafminer** (p.27)



  - Head with short snout; dark brown or gray
    Clover root curculio (p.24)



Coleopterous Pests:
Beetles, Chafers, and Small Larvae or Grubs

Bean leaf beetle
Cerotoma trifurcata

Description and habits. The adult beetles are small (about ¼ inch long) with considerable variation in color pattern. The background color may be light yellow to crimson. Wing covers may have four main black spots and stripes, but these markings may be absent. A black triangle is always present behind the thorax. Females lay reddish, spindle-shaped eggs in the soil next to a plant crown. The larvae are whitish and cylindrical with dark brown areas at both ends. Pupation occurs inside small earthen cells in the soil. Adults feed on soybean foliage, cutting small rounded holes in the leaves. Larvae feed underground on roots and nodules.

Seasonal life history. In Illinois the adults overwinter under litter in woodlots near crop fields. The beetles become active in spring soon after the temperature rises above 50 to 55°F. At this time they fly into alfalfa and clover fields, but do not lay eggs there. They also feed on some weedy herbs. As soon as soybean seedlings emerge in late May, the beetles abandon the forage fields and colonize the soybean fields. Here they feed on emerging seedlings and oviposit in the soil near the plants. Larval development is slow at first, usually taking 45 to 50 days under the cool soil temperatures of late spring.

Bean leaf beetle, common color pattern. 3X.

Bean leaf beetle, red form. 4.5X.

Michael Jeffords

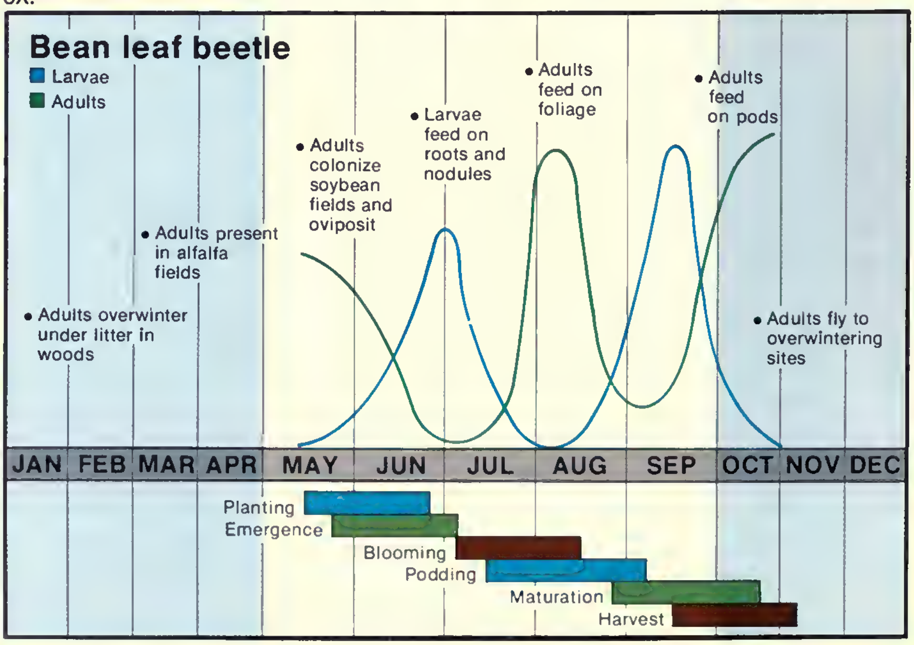


Fig. 23. Annual cycle of the bean leaf beetle in Illinois.

Adults of the first generation begin to emerge in mid-July, but the peak comes in late July or early August. These beetles start ovipositing, and the new larvae emerge as second-generation adults at the beginning of September. They do not lay eggs, although they stay in soybean fields as long as there are green leaves or tender pods to chew on. As soybeans mature, the beetles again fly into alfalfa fields. When the temperature falls, they fly into the woods to overwinter. A summary of the annual cycle of the bean leaf beetle in Illinois is shown in Figure 23.

Michael Jeffords

Bean leaf beetle, spotless form. 4X.

Bean leaf beetle larva. 5.5X.

Blister beetles

Epicauta spp.

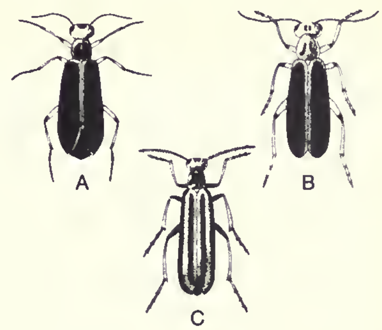
Description and habits. Blister beetles are elongated and have comparatively soft bodies. The head is broader than the prothorax, the section between head and wings. Thus it appears that the insect has a neck. The wing covers are soft and flexible, and the legs long and slender.

Striped blister beetles (*E. vittata*) are about ⅝ inch long and a fourth as wide. They are gray to brown with yellow stripes running lengthwise on the wing covers. Ashgray blister beetles (*E. fabricii*) are about ½ inch long and are completely gray. Black blister beetles (*E. pennsylvanica*) are also about ½ inch long but are solid black. Margined blister beetles (*E. pestifera*) vary from ½ to ⅝ inch and are black with a gray to cream band around the edge of each wing cover.

Blister beetles lay egg masses in soil where grasshoppers normally deposit eggs. A newly hatched larva searches for a grasshopper egg pod, and upon finding one chews its way into the pod and begins to feed. At the last molt, the larva crawls out of the egg pod, pupates in the soil, and emerges as an adult in 10 to 20 days. These insects overwinter primarily as almost mature larvae. There is probably only one generation a year.

The larvae of the common blister beetles are beneficial because they destroy grasshopper egg pods. Heavy infestations often occur during or just after a grasshopper outbreak. But even though the larvae are beneficial, the adults are not. Striped blister beetles, the species most commonly found on soybean, may aggregate in large clusters in certain rows and cause extensive defoliation. The other species feed mainly on the flowers and pollen of alfalfa and weeds along field margins.

Blister beetles are so named because their body fluid contains cantharidin, an oily substance that causes large blisters to form when it touches a person's skin.



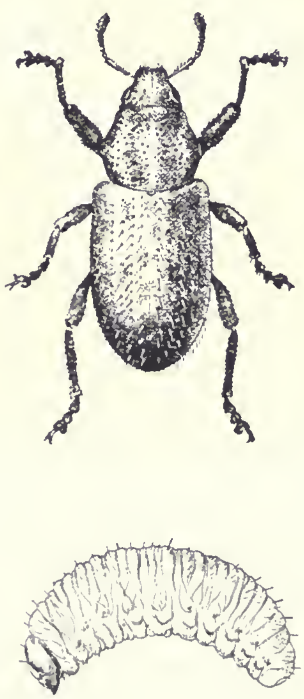
Three species of blister beetles: A, margined; B, black; C, striped.

Michael Jeffords

Blister beetles. 2X.

Clover root curculio
Sitona hispidula

Description and habits. Adults are gray to light brown, blunt-snouted beetles about 1/6 inch long. At the slightest disturbance they "play dead." The grayish-white, legless larvae are found in the soil around the roots of host plants. Primarily a pest of alfalfa and clover, these beetles occasionally feed on the foliage of soybean plants growing mainly in the marginal rows adjacent to newly plowed alfalfa or clover fields. The adults are active at night, spending the day in debris on the soil. Clover root curculios overwinter mainly as larvae, but a few may spend the winter as adults or eggs. There is usually only one generation each year.



Clover root curculio, adult and larva. 10X.

Dectes stem borer
Dectes texanus texanus

Description and habits. Adults are gray, are about 5/8 inch long, and have long, slender antennae. The small eggs are deposited singly in cavities that the beetles chew along leaf petioles. As the larvae emerge, they eat the pith. Fully grown larvae are creamy white and are 1/2 to 5/8 inch long. Tunneling into the main stem near ground level, the larvae girdle the stem and overwinter in girdled stubble in the ground. Under strong winds or heavy rain, the stems break at the girdled point. *Dectes* occurs in Illinois, but so far has seldom been observed feeding on soybean.

Michael Jeffords

Dectes stem borer. 2X.

Grape colaspis
Colaspis brunnea

Description and habits. Adults are about 1/8 inch long, are tan, and have wing covers marked with rows of tiny punctures. The soil-dwelling larvae are grayish-white and grublike. Pupation occurs in the soil inside earthen cells. Adults feed on soybean foliage, and larvae feed on the lateral roots. These insects are seldom very abundant in Illinois, but when they occur in large numbers, plants may become stunted in patches within a field. Damage may be a problem in soybean grown for two or three successive years in poorly drained soils or when soybean follows clover, lespedeza, or a heavy stand of smartweed.

Grape colaspis larva. 4X.

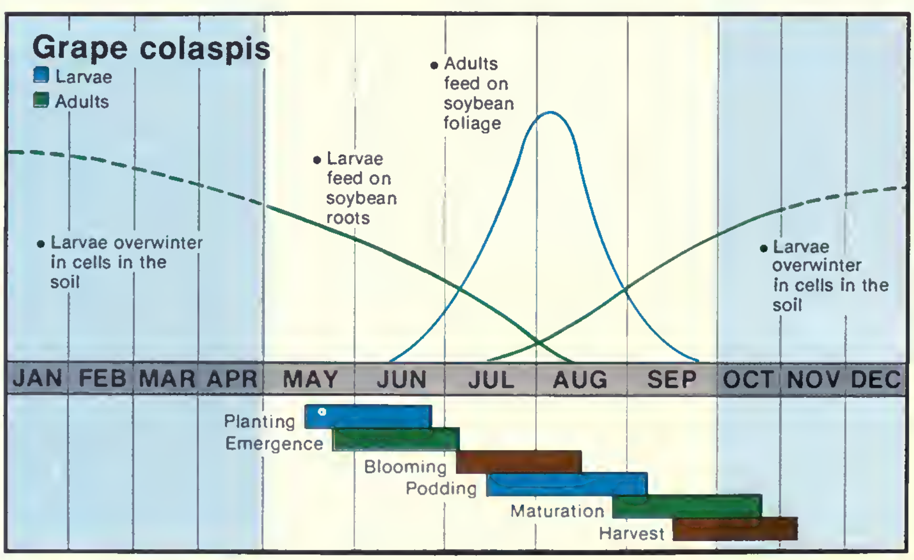


Fig. 24. Annual cycle of the grape colaspis in Illinois.

Seasonal life history. The grape colaspis overwinters as larvae in cells in the soil. In spring as the temperature rises, they move upward to feed on small roots and the lower parts of the main stem. There is one generation per year. A summary of the annual cycle is shown in Figure 24.

Grape colaspis adult. 5X.

Japanese beetle

Popillia japonica

Description and habits. The beetle is ⅓ to ½ inch long. It is a shiny metallic green or greenish-bronze with reddish wing covers and two white spots at the tip of the abdomen. A row of smaller white spots is located along each side of the abdomen. The larvae or grubs are white, but may appear gray from ingested soil. They have a row of V-shaped spines on the underside of the tip of the abdomen; the bottom of the V points toward the head. The spines can be seen easily with a hand lens.

Seasonal life history. Having a one-year life cycle, Japanese beetles spend about 10 months as grubs in the soil. They overwinter as partly grown grubs and complete their growth during June, when they transform into pupae. The first adults emerge during late June. They are present during July and August, and a few can still be found in early September. In rural areas they are present mainly on the foliage of smartweed, soybean, wild grapes, and corn silks. In urban areas the beetles feed on foliage and on the fruits of many trees, shrubs, and flowering plants.

From late June until early September, the beetles deposit eggs 2 to 6 inches deep in the soil. The newly hatched grubs feed first on decaying vegetable matter and later on the roots of grasses and other plants. When the soil cools in late October and early November, the grubs become inactive and do not feed until the following spring. They are seldom a problem in soybean fields, but the adults may cause severe defoliation in some Illinois counties.

Sue Post

Japanese beetles. 2X.

Mexican bean beetle
Epilachna varivestis

Description and habits. Although found in garden beans throughout the state, Mexican bean beetles seldom attack soybean in Illinois. However, beetles of a soybean-feeding strain are a serious pest in parts of Indiana and some eastern states. Their occurrence on soybean in Illinois should therefore be carefully monitored.

Resembling lady beetles, the adults are yellow to copper-colored and are ¼ to ⅓ inch long. Each wing cover has eight black spots in three rows across the body. The fully grown larvae are a brighter yellow than the adults and are ⅓ inch long. Each body segment has six branched spines.

Larvae chew the leaves, depositing lacelike windrows of crushed tissue from which the juices have been extracted. Adult beetles eat holes in the leaves and make superficial scars on the pods. They attack seedlings early in the season, and increased populations in July and August cause considerable defoliation.


Michael Jeffords

Mexican bean beetle eggs. 5X.

Seasonal life history. Adult beetles hibernate in woodland areas, and come out of hibernation in the spring. Invasion of soybean fields occurs as soon as plants emerge. Females lay clusters of yellow, elongated eggs on the underside of leaves. Larvae emerge within 5 to 14 days, depending on the weather, and are fully grown in 3 to 5 weeks. They pupate attached to leaves, the adults emerging about 10 days after pupation. There are probably three generations per year in Illinois.


Michael Jeffords

Mexican bean beetle larva. 4X.


Michael Jeffords

Mexican bean beetle pupa. 4X.

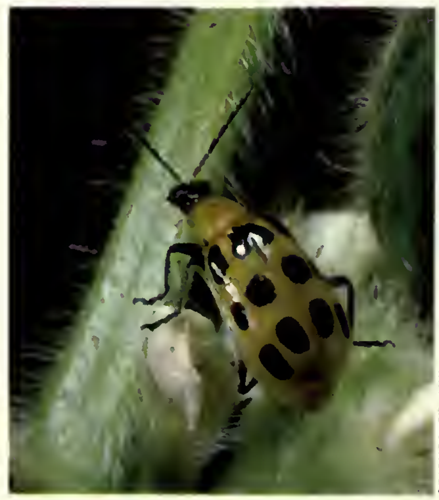

Michael Jeffords

Mexican bean beetle adult. 4X.

Rootworm beetles
Diabrotica spp.

Description and habits. Adults of the northern corn rootworm (*D. longicornis*) are green to yellow beetles about ¼ inch long. The small, white, globular eggs are found in the soil around cornstalks. The larvae, which damage the roots, are threadlike white worms about ½ inch long when fully grown. The pupae are short, white, and stout, and are found in an earthen cell.

Adults of the southern corn rootworm (*D. undecimpunctata howardi*), also known as the spotted cucumber beetle, are about ⅜ inch long, are yellow to green, and have eleven black spots on the wing covers. The eggs, larvae, and pupae resemble those of the northern corn rootworm.


Michael Jeffords

Southern corn rootworm beetle. 6X.

Adults of the western corn rootworm (*D. virgifera*) are pale yellow-green beetles about ¼ inch long with black stripes on the wing covers. The eggs, larvae, and pupae are similar in appearance and habit to the northern species. The western adults are very active and will fly at the slightest disturbance. Consequently, they are more difficult to capture than either the northern or the southern corn rootworm adults. Primarily pests of corn, adults of the western species may be found feeding on soybean foliage and blossoms.

Michael Jeffords

Western corn rootworm beetle. 7X.

Michael Jeffords

Northern corn rootworm beetle. 6X.

Soybean leafminer

Odontota horni

Description and habits. The adults are small beetles about ¼ inch long and ⅛ inch wide. They are brick-red with a black head and a black line along the middle of the wing covers. The flat eggs are laid mainly on the underside of leaves. The larvae are a bright orange and are a little over ¼ inch long when fully grown. They have three pairs of legs and a series of pointed expansions on both sides of each body segment. Pupation occurs in the mined space between the upper and lower epidermis of leaves.

Soybean leafminer larva. 6X.

Soybean leafminer adult. 3.5X.

Adults feed on soybean foliage, leaving scars that resemble those from the feeding of Mexican bean beetles. After emerging from their eggs, the larvae penetrate the leaf tissue, where they form a rounded, irregular mine. The epidermis of mined areas dries out, and dry spots similar to those caused by some foliar diseases remain. The beetles, which may have two generations a year in Illinois, probably overwinter as adults.

Mine in soybean leaf. 1X.

White grubs

Phyllophaga spp. and *Cyclocephala* spp.

Description and habits. White grubs, which are the larvae of June beetles and several species of chafers, have a C-shaped body, a brown head, and three pairs of legs. The body is white and soft; the tip of the abdomen is shiny and transparent. True white grubs (*Phyllophaga*) are distinguished from annual white grubs (*Cyclocephala*) by the patterns on the ventral surface of the last abdominal segment (see keys in Figure 22). The adults of both genera are light tan to black beetles ½ to ¾ inch long. They deposit pearl-white, spherical eggs singly in the soil. Larvae feed on roots, and extensive feeding may kill soybean plants or severely stunt them. True white grubs may have a life cycle of 2 to 4 years, but a three-year cycle is most common. Annual white grubs, as the name indicates, have a one-year life cycle.

White grub. 2.5X.

Beetle of white grub. 1.5X.

Wireworms

Larvae of *Limonius*, *Melanotus*, *Conoderus*, and other genera of Elateridae or the click beetles

Description and habits. Several species of wireworms, all quite similar in appearance, attack the roots of many crops. When young, the cream-colored worms are about ¼ inch long and less than 1/16 inch in diameter. When mature, they are 1¼ to 1½ inches long and about ⅛ inch in diameter. Adults are click beetles: when placed on their backs, they flip into the air with an audible snap and then land on their feet. The eggs are tiny white globules laid in the soil. The larvae drill holes in the underground part of soybean stems and roots, and may also destroy seeds before germination. Wireworm larvae may live from 2 to 6 years in the soil, feeding on the roots of weeds, grasses, and crop plants. The pupal stage, which lasts perhaps 2 weeks, is spent in a cell in the soil. With such a long life cycle, one generation may require 6 or 7 years for completion.

Wireworm beetle. 2X.

Wireworm. 1.5X.

Hemipterous Pests:
Stink Bugs, Flower Bugs

Green stink bug
Acrosternum hilare

Description and habits. Adults are large (about 5/8 inch long), light green bugs that are triangularly shaped. They have slender antennae with five segments each. The female lays egg masses averaging 30 eggs. Barrel-shaped and closely packed together, the eggs are initially pale green, turning yellow, pinkish, and finally bright pink as they approach hatching.

Small, round, reddish-brown nymphs hatch in about 12 days, depending on weather conditions. The nymphs remain aggregated on or near the egg mass without feeding. They molt in 5 to 7 days, and the second instar nymphs begin to feed. Undergoing three additional molts, they grow and acquire a varied color pattern with black, green, and yellow or red areas. Fifth instar nymphs are about 1/2 inch long and have clearly defined wing pads. The entire nymphal period from egg hatch to adult emergence lasts about 45 days. The life cycle of the green stink bug is shown in Figure 25.

Both adults and nymphs have sucking mouthparts and feed on plant juices. Older nymphs and adults prefer feeding on fruiting

Newly emerged nymphs of the green stink bug. 3.5X.

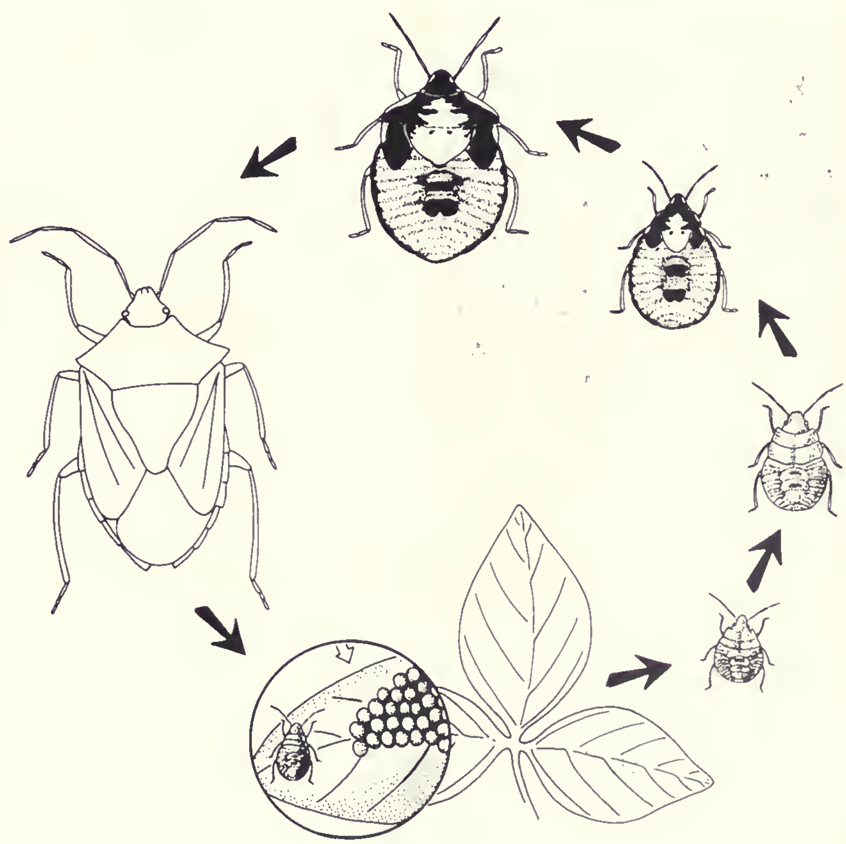


Fig. 25. Life cycle of a typical stink bug.

structures. Much of the stink bug damage to soybean is due to feeding on seeds. Young seeds usually abort, and older ones may be discolored or malformed in varying degrees. If a bug punctures the embryo, the seed will not germinate. Stink bugs also transmit the organism that causes yeast spot disease.

Seasonal life history. Green stink bugs seem to overwinter as adults in woods. Early summer adults feed on berries in trees, especially dogwoods. Invasion of soybean fields normally occurs after pods begin to set towards mid or late August. Usually there is one generation of green stink bugs on soybean; the bulk of the overwintering population is probably from this generation. A diagram of the seasonal life history of the green stink bug in Illinois is shown in Figure 26.

Other species of stink bug are similar in feeding habits and biology to the green stink bug. One of these species, the brown stink bug (*Euschistus servus*), should not be confused with the beneficial spined soldier bug (*Podisus maculiventris*) (Fig. 42). You can tell them apart rather easily: in *Euschistus* the beak is slender and embedded between the lateral parts of the head; in *Podisus* the base of the beak is stout and free from the lateral parts. *Podisus* has a dark round spot centered on the underside of the abdomen. In the southern and eastern states, the southern green stink bug (*Nezara viridula*) causes more damage to soybean than do other stink bugs. It is rarely found in Illinois, however.

Fifth instar nymph of the green stink bug. 2.5X.

Green stink bug adult. 2.5X.

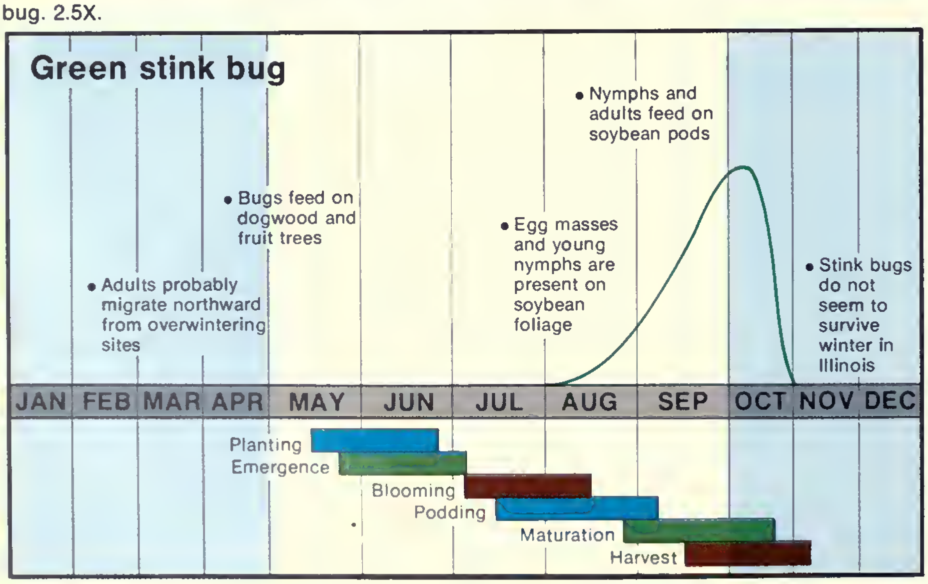
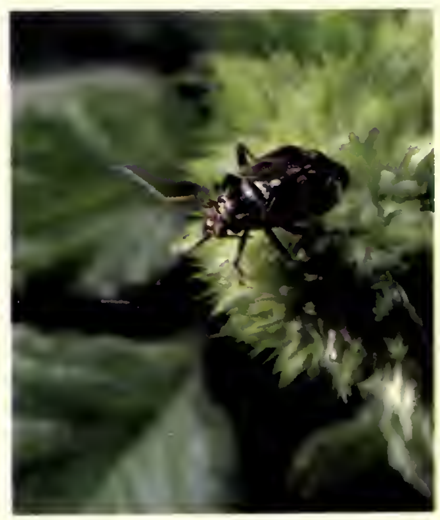


Fig. 26. Annual cycle of the green stink bug in Illinois.

Tarnished plant bug
Lygus lineolaris

Description and habits. Adults of the tarnished plant bug are about 1/4 inch long and 1/8 inch wide. They are brown, mottled with white, yellow, and black. The nymphs, resembling adults in body contour, are green with five tiny black dots on the back. Having sucking mouthparts, the adults and nymphs feed on many species of cultivated and wild plants and are usually very abundant in alfalfa fields. When on soybean, they prefer the blossoms and very young seeds, but the extent of damage, if any, is not well known.

Tarnished plant bugs overwinter as adults in the debris of legume fields, fencerows, wooded areas, and ditch banks. In early spring these bugs leave their hibernating quarters to begin feeding. The females deposit eggs in the stems, leaf midribs, and petioles of flowers of various herbaceous plants. Nymphs hatch, feed, and mature in 3 to 4 weeks. There are three to five generations each year.



Tarnished plant bug. 4X.

Lepidopterous Pests:

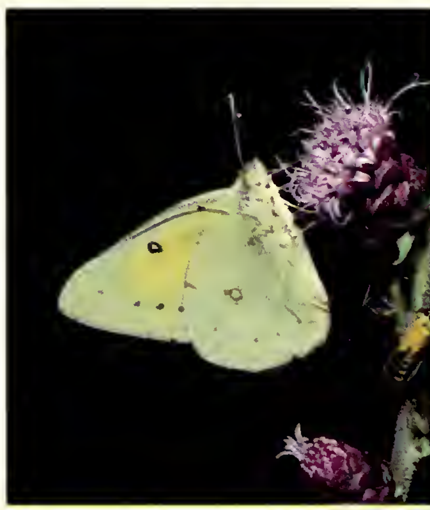
Caterpillars of Moths and Butterflies

Alfalfa caterpillar

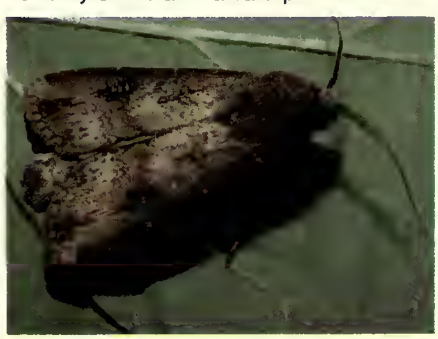
Colias eurytheme

Description and habits. The larvae of this yellow butterfly are primarily pests of alfalfa, but they are also commonly found feeding on soybean leaves. The fully grown larvae are 1½ inches long. Each side of the dark gray-green body has a thin white stripe through which runs a very fine red line. They pupate on plants without spinning a cocoon and overwinter as pupae. Illinois probably has two or three generations per year.

Alfalfa caterpillar. 1.5X.



Butterfly of the alfalfa caterpillar. 1X.



Moth of the black cutworm. 2X.

Black cutworm

Agrotis ipsilon

Description and habits. Fully grown larvae are 1½ inches long. Light gray to almost black, they can be distinguished from other cutworms by the isolated skin granules on the body. These granules are convex, shiny, and very large. The pupae are brown and spindle-shaped. The moths, which are nocturnal, are difficult to distinguish from several other species of cutworm moths. The females lay their ribbed, globular, white eggs in clusters of 10 to 30 near a supply of larval food.

Cutworms remain hidden in the soil during the day, but may feed below the soil surface. Since their color blends with the soil, they can be easily overlooked. To find them, carefully examine the soil for about 3 inches on each side of a freshly cut plant and 3 inches below the soil surface. Small soybean seedling grown on fields that were covered with weeds early in the spring are sometimes cut by these worms at ground level.

Black cutworms probably do not overwinter in significant numbers in Illinois, but rather migrate here from the South. Usually appearing in late March and early April, the moths seem to prefer laying their eggs in low, muddy spots in fields and overflow ground. Development from egg to adult requires more than 45 days. This cycle continues until frost, three or four generations being produced each year.

Black cutworm larva. 1X.

Corn earworm
Heliothis zea

Description and habits. Corn earworm larvae vary greatly in color, ranging from light green or pink to dark brown or nearly black. Full-grown larvae are about 1½ inches long. They are marked with alternating light and dark stripes running the entire length of the body. These stripes are not always the same from one larva to the next, but usually a dark double line runs down the back. The adults are moths having a wing spread of about 1½ inches. The front wings are light brown to tan, marked with dark irregular lines and a dark area near the tip of the wings. The females lay small, pearly white eggs singly on the host plants.

Corn earworms do not overwinter in Illinois, but migrate northward as moths in May and June. In Illinois, the earworms prefer corn. In the southern states, however, they are considered one of the most serious pests of soybean, feeding on both foliage and pods.

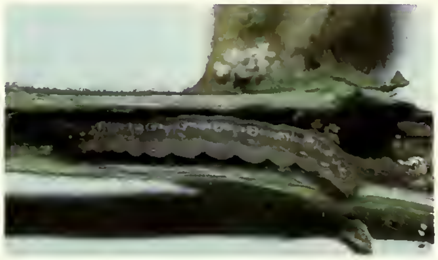
Corn earworm. 1X.

Michael Jeffords

Moth of the corn earworm. 1.5X.

European corn borer
Ostrinia nubilalis

Description and habits. European corn borers are typically a pest of corn, but the larvae may occasionally bore soybean stems. The caterpillars are ½ to 1 inch long. The body is flesh-colored, with small round spots that are a pale brown. Pupation occurs inside bored stems. The adults are small moths. Females are yellowish brown with dark bands running in wavy lines across the wings; males are darker than females. We have no record of economic infestations of soybean in Illinois.



European corn borer. 2X.

Fall armyworm
Spodoptera frugiperda

Description and habits. Full-grown larvae are 1½ inches long and vary from light tan to nearly black. They have three yellowish-white hairlines down the back from head to tail. On the sides and next to the yellow lines is a wider, dark stripe, and next to it an equally wide, somewhat wavy, yellow stripe splotched with red. These worms resemble the true armyworm and corn earworm, but can be distinguished from them by the prominent inverted Y on the front of the head.

Fall armyworm moths are about ¾ inch long and are a dark gray, mottled with light and dark splotches and with a noticeable white spot near the extreme tip of the front wings. The spherical gray eggs are laid in clusters of about 150, usually on leaves of host plants, and are covered with a coating of body scales and hairs.

The fall armyworm spends the winter in the southern states. It flies into Illinois every year, arriving from midsummer on. Populations may become very abundant by late August or early September. Although the larvae are primarily a pest of corn, occasionally they attack the foliage of soybean in Illinois.

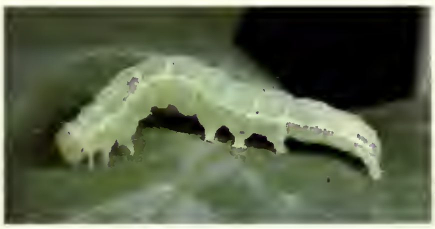
Michael Jeffords

Fall armyworm. 1.2X.

Green cloverworm

Plathypena scabra

Description and habits. Like all butterflies and moths, the green cloverworm goes through four distinct stages: egg, larva, pupa, and adult. There are usually six larval instars (Fig. 27). The worms are a light green with two thin white stripes along each side of the body. When fully grown, these slender worms are about 1 inch to 1½ inches long. They have only three pairs of prolegs on the abdomen, not counting the pair on the tip. Cloverworms move by arching their body. If disturbed, they wriggle violently from side to side.



Merle Sheppard

Green cloverworm. 2X.

Moth of the green cloverworm. 2.5X.

The small green eggs are laid on the underside of leaves. Young larvae are very difficult to see, but in heavy infestations if you look against a bright sky, you can see the tiny larvae hanging by fine threads from the underside of leaves. Young larvae scrape the leaf tissues so that the transparent skin of the leaves resembles irregular, shiny windows on the surface. Older larvae eat holes in the leaves, which then become ragged as the wind tears the edges around the holes. Active at dusk, the adults are dark brown moths with black spots and a wing span of about 1¼ inches.

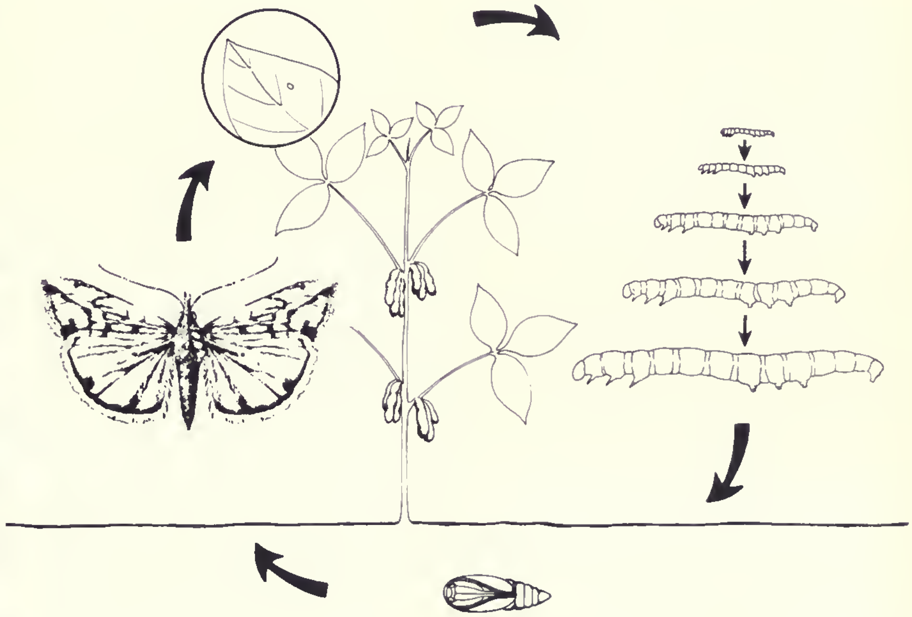


Fig. 27. Life cycle of the green cloverworm.

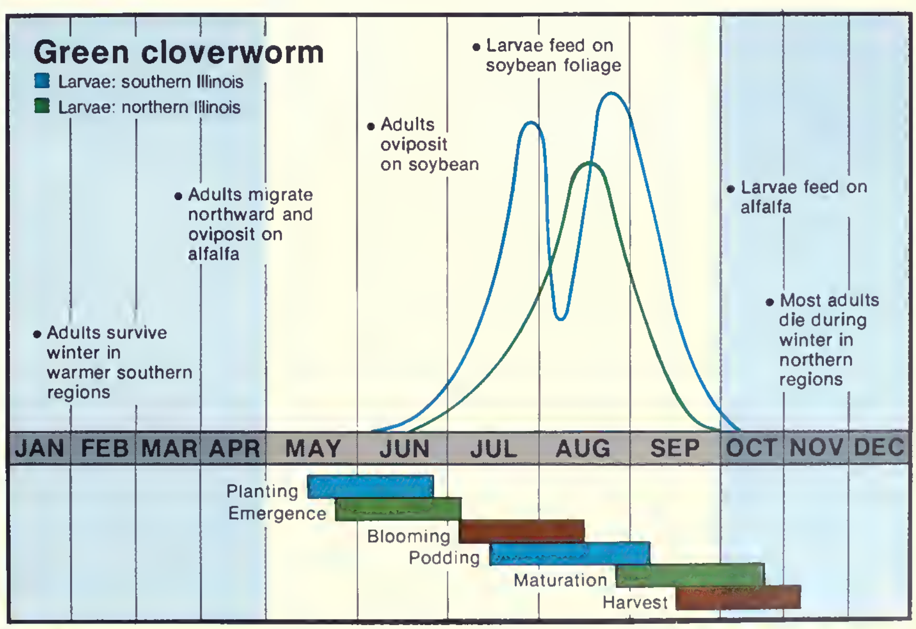


Fig. 28. Annual cycle of the green cloverworm in Illinois.

Seasonal life history. Green cloverworms are not likely to overwinter in central and northern Illinois. Instead, they probably fly northward from breeding sites in the South each spring. The adults then oviposit here on soybean and alfalfa. Two peaks of larval populations can be observed in southern Illinois during the second half of July and the middle of August. As a rule, generations overlap in central and northern Illinois. One major peak is usually detected early in August in the central part of the state and late in the month farther to the north. Figure 28 shows the annual cycle of the green cloverworm in Illinois.

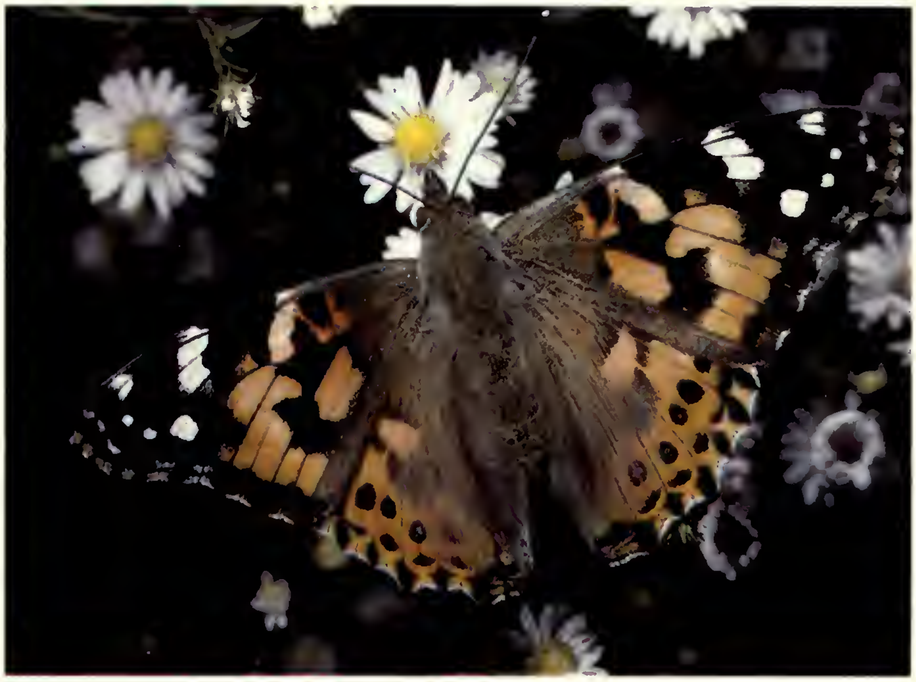
Painted lady caterpillar

Cynthia cardui

Description and habits. The painted lady is a nearly cosmopolitan butterfly, breeding in the southern regions of the United States, then migrating northward in the spring. The butterfly has beautifully mottled red, dark brown, and white wings about 1⅞ inches in width. The larva, a mottled yellowish green and black with a lateral yellow stripe, is covered with yellowish spines. It lives singly in a nest of leaves woven together by silken threads and feeds mainly on thistles. But sometimes the migrating butterflies oviposit on young soybean plants, which are attacked by the hatched larvae. Occasional infestations have been observed in Iowa and Illinois.

Larry Pedigo

Painted lady larva. 1.5X.



Michael Jeffords

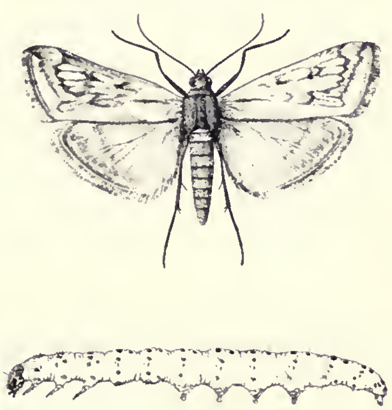
Painted lady butterfly. 2X.

Webworms

Loxostege spp.

Description and habits. Garden and alfalfa webworms are about 1 inch long and are green to yellow-green with three black spots on the side of each body segment. One to three bristlelike hairs project from these spots. The moths have a wingspread of ¾ inch and are buff colored with irregular markings of light and dark gray. They lay their eggs in masses on plants.

Webworms overwinter in the soil as pupae. Early in the spring the moths emerge and lay their eggs on host plants. Protected by a fine web, the larvae feed on the underside of leaves. After becoming full grown in about 4 weeks, the webworms then pupate in the soil. One generation requires about 6 weeks, and there are usually three to five generations each year.



Webworm, adult 2.5X and larva 2X.

Yellowstriped armyworm

Spodoptera ornithogalli

Description and habits. Yellowstriped armyworm larvae are velvety brown or black with a bright yellow stripe along each side of the body. When fully grown, the larvae are ¾ inch to 1½ inches long. They feed on the foliage of many plants, including soybean. The adults, which are gray moths with distinct markings on the wings, lay their eggs on stems or leaves. They do not seem to overwinter in Illinois, but migrate northward from breeding sites in the South.

Michael Jeffords

Yellowstriped armyworm. 1X.

Yellow woollybear

Diacrisia virginica

Description and habits. The adult woollybear, a white-winged moth with a wing span of 1½ to 2 inches, lays clusters of round white eggs on leaves. The extremely hairy larvae are white when young, but turn dark brown or reddish as they grow older. Although all instars feed voraciously on soybean leaves, the larvae are found on many other cultivated and wild plants as well. Woollybears overwinter as pupae inside silken cocoons heavily covered with interwoven hairs from the body of the caterpillar.

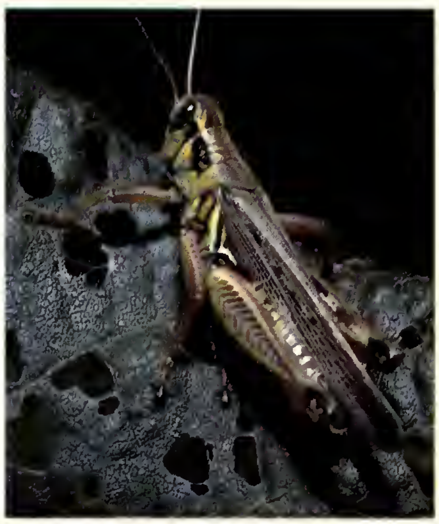
Usually there are two generations a year in Illinois. Heavy infestation commonly occurs late in the season, but quite often the dense populations are decimated by a disease caused by a fungus of the genus *Entomophthora*.

Yellow woollybear larva. 1.2X.

Orthopterous Pests:
Grasshoppers

Grasshoppers
Melanoplus femurrubrum and
M. differentialis

Description and habits. Several species of grasshopper invade soybean fields in Illinois. The most common are the redlegged grasshopper and the differential grasshopper. Young nymphs look like adults, but are much smaller and wingless. In 40 to 60 days they become adults. Strong fliers, the adults have stiff outer wings that cover clear, membranous flying wings, which fold like a fan under the outer pair. Both adults and nymphs feed voraciously on the foliage of soybean and other plants, and also on green soybean pods.



Differential grasshopper. 1.3X.

Seasonal life history. Eggs are laid in the soil in batches of 20 to 30 early in the fall. Until the first frost, each female may lay up to 20 batches. The eggs do not hatch until the following spring. Nymphs feed mainly on plants in ditch banks and fencerows and then invade the border rows of soybean fields as the noncrop food plants are mowed or dry out. Grasshoppers usually invade soybean fields in the second half of the growing season. The life cycle and the annual cycle are shown in Figures 29 and 30.

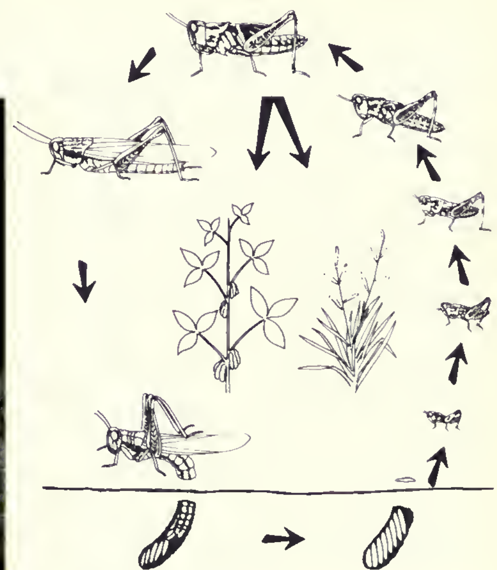


Fig. 29. Life cycle of a grasshopper.

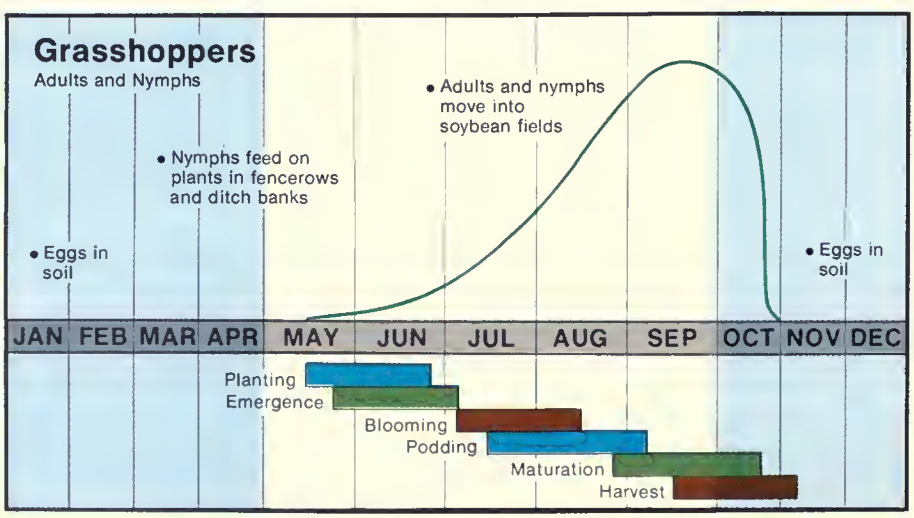


Fig. 30. Annual cycle of grasshoppers in Illinois.

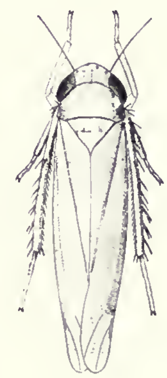
Other Pests

Potato leafhopper
Empoasca fabae

Description and habits. Adults of the potato leafhopper are small (about ⅛ inch long), wedge-shaped, and pale green with very small white spots on the head and thorax. Nymphs are similar to adults in color and shape but are wingless. Leafhoppers feed on the underside of leaves, and if disturbed move sideways to the opposite side of the feeding area. When populations are abundant, their sap sucking can cause a condition known as hopperburn.

Seasonal life history. Potato leafhoppers overwinter primarily on alfalfa and other legumes in fairly permanent breeding areas in the Gulf States. These pests appear in large numbers on alfalfa and soybean as soon as the crops begin to grow in the spring and early summer. Eggs are laid singly, embedded in plant tissues. Development of nymphs during the summer may take only 10 to 15 days; thus, several generations are possible each season on soybean. A summary of the annual cycle is shown in Figure 31. Other species of leafhopper also inhabit soybean fields.

Potato leafhopper nymph. 10X.



Potato leafhopper adult. 10X.

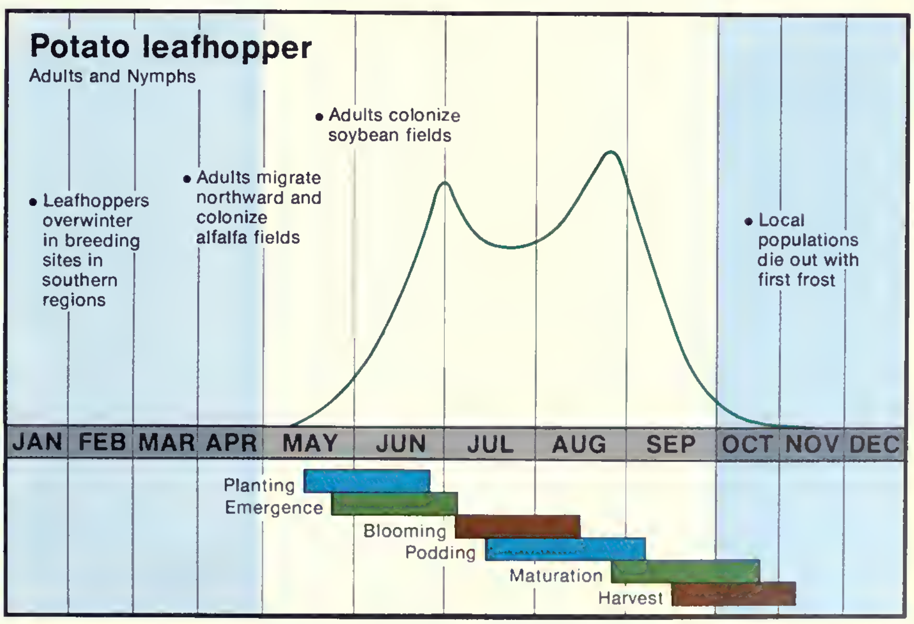


Fig. 31. Annual cycle of the potato leafhopper in Illinois.

Seedcorn maggot
Delia platura

Description and habits. The yellowish-white maggots are about ¼ inch long, cylindrical, narrow in front, and legless. When fully grown, they turn into reddish-brown puparia, from which emerge grayish-brown flies similar to house flies but smaller and thinner. Feeding on seeds that may not have germinated or on weak seedlings, the maggots are especially damaging when air and soil temperatures are cool.

Seedcorn maggots attacking a germinating seed. 5.5X.

Seasonal life history. The flies are active in the spring after overwintering as pupae inside puparia in the soil or as maggots in manure. Developing at any temperature above 52°F, the maggots complete development in about 3 weeks. They are present in soybean fields early in the season. The annual cycle is summarized in Figure 32.

Seedcorn maggot adults (two views), puparium, and maggot. 5X.

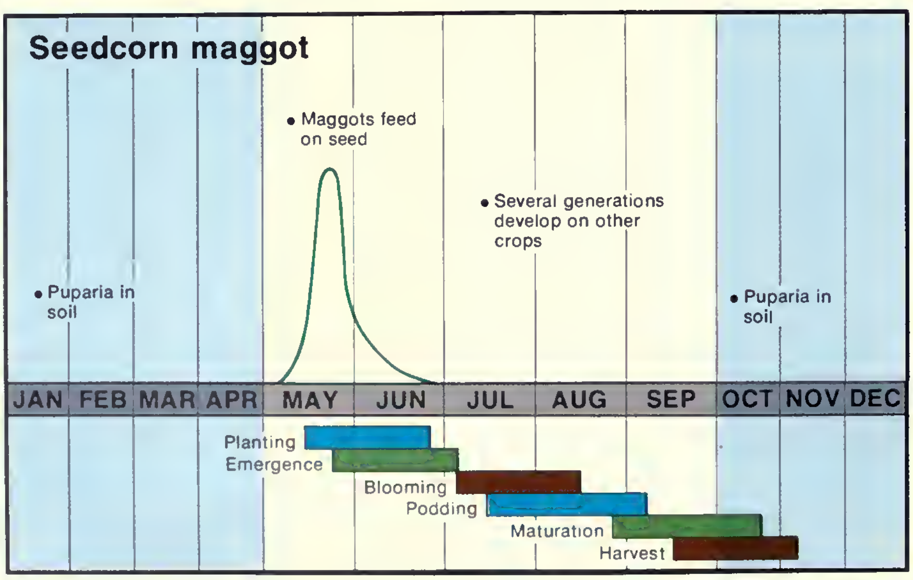
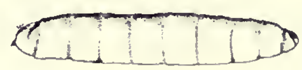


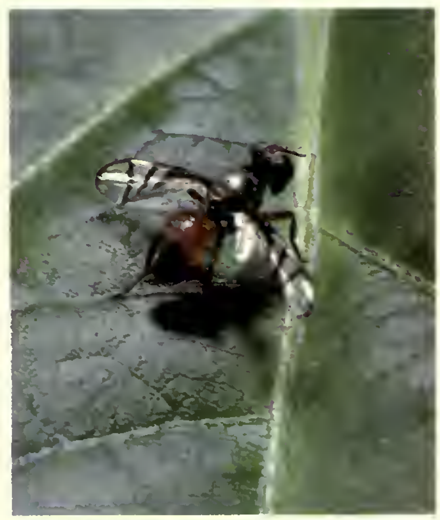
Fig. 32. Annual cycle of the seedcorn maggot in Illinois.

Soybean nodule fly
Rivellia quadrifasciata

Description and habits. Adult flies are about 3/16 inch long with a russet head, black thorax, and reddish-yellow abdomen. Their wings are marked with four black bands; the lower parts of the legs are yellow. The flies lay small, chalky to creamy white eggs in the soil. After emerging, the larvae or maggots bore holes in soybean nodules and consume the contents. When fully grown, the larvae are about ¼ inch long. Although these flies are present in Illinois, the amount of nodule damage they produce is probably insignificant.



Maggot of the soybean nodule fly. 5X.



Soybean nodule fly. 4.5X.

Soybean thrips

Main species: *Sericothrips variabilis*

Description and habits. Thrips insert their eggs into plant tissue. The hatched, orange-red larvae remain on the plant through the second instar, then drop to the soil, where the prepupae and pupae stay until adult emergence. The tiny adults (0.04 inch) are banded transversely and have wings that are typically fringed with long bristles. Both nymphs and adults feed actively on soybean.

Soybean thrips adult. 40X.

Seasonal life history. Soybean thrips do not overwinter in Illinois, but are carried northward on warm airstreams from breeding sites in the South. Thrips colonize soybean as soon as the plants emerge. Generations overlap each other because the life cycle is completed in about 15 days. A summary of the annual cycle in Illinois is shown in Figure 33.

Soybean thrips larva. 35X.

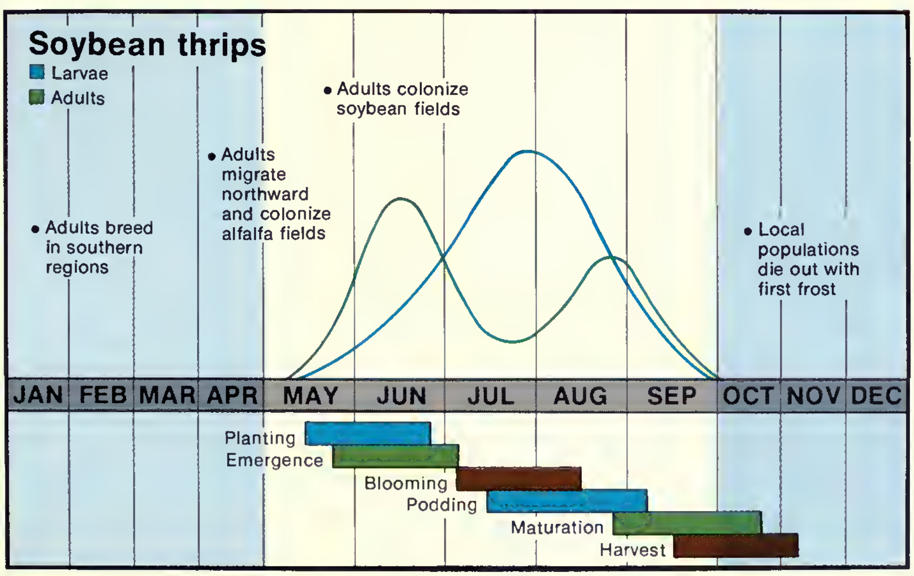


Fig. 33. Annual cycle of the soybean thrips in Illinois.

Whiteflies

Trialeurodes spp.

Description and habits. Tiny (1/16 inch long) but very lively, the adult whitefly has a yellowish body and four wings covered with a powdery wax. The small eggs are attached to the leaf surface by a short stalk. Emerging nymphs settle on nearby leaves, feeding actively on plant juices until reaching the adult stage. The nymphal stage lasts about 30 days. Whitefly injury results in a yellow speckling of leaves, and when injury is heavy, the leaves become dry. Occasional field infestations are found in Illinois, particularly in the southwestern part of the state.

Whiteflies. 5.5X.

Spider mites
Tetranychus spp.

Description and habits. The most common mite species found on soybean in Illinois is the twospotted spider mite, *T. urticae*. These tiny mites (0.002 inch) are four-legged, red arthropods, more closely related to spiders than to insects. Stages of growth and development include egg, larva, protonymph, deutonymph, and adult (Fig. 34). The life cycle is completed in 10 to 20 days, depending on weather conditions.

Mites are passively dispersed into fields by wind, animals, farm equipment, or workers, but may also crawl from weedy hosts to soybean plants. Thus infestations often start along the borders of fields or in spots within fields. When populations are large, mites produce webbing that helps them spread from one plant to another.

Initial injury results in a yellow speckling of the leaves (Fig. 13); heavy infestations cause leaves to wilt and become dry. Occurring by mid to late season, most outbreaks of spider mites in Illinois are usually associated with prolonged drought.

Spider mites. 6X.

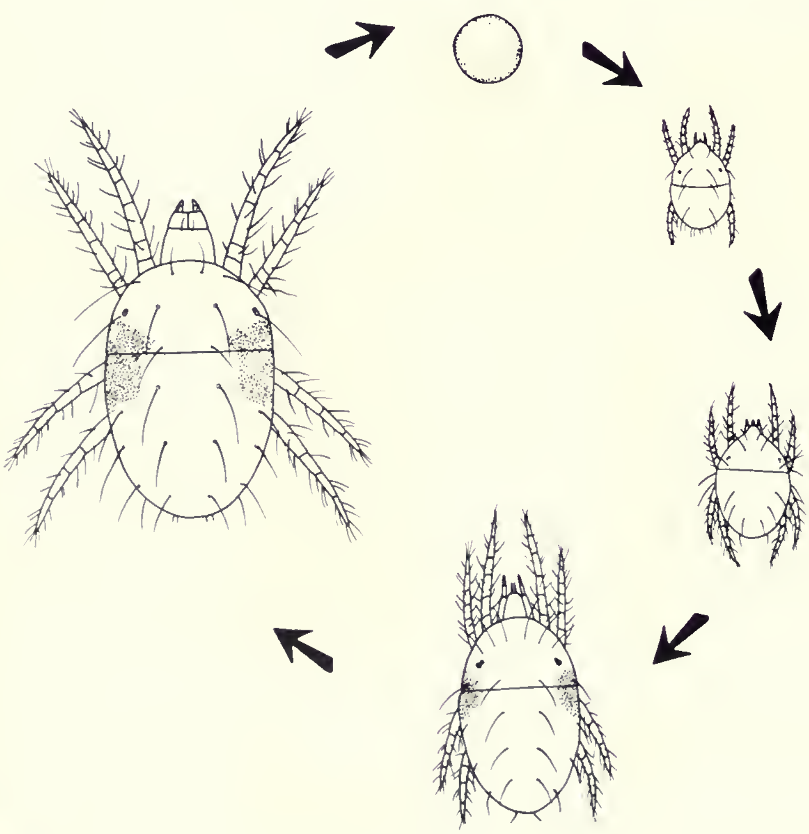


Fig. 34. Life cycle of the twospotted spider mite.

Biological Control Agents

Most soybean insect pests in Illinois are attacked by natural enemies, or biological control agents. These agents are predaceous and parasitic insects, spiders, insect-eating birds, toads, and insect diseases. The most effective of these agents in Illinois soybean fields are the beneficial insects and insect diseases, which usually help to keep pest populations well below the economic injury level.

It is important that you recognize the presence of these agents. If they are destroyed by unnecessary or ill-timed chemical applications, considerable harm may be done. The worst problems arise from triggering a secondary pest explosion or from a resurgence of the target pest.

Most parasitic insects of soybean pests are small wasps and flies whose identification requires the help of a specialist. However, pest managers should be able to detect the presence of beneficial insects. The Illinois pest management program is designed to preserve these agents and to take advantage of the natural control they provide.

Parasites

The most visible parasites are those found on lepidopterous caterpillars. At least eleven species of parasitic wasps and flies attack green cloverworms in the Midwest. The most important parasites are larvae of the wasp *Apanteles marginiventris* (Fig. 35) and maggots of a tachinid fly that lays small white eggs easily seen behind the head of the larvae. Late in the season, mummified caterpillars that look like small cigars can be found attached to soybean leaves. These shells are the skins of cloverworm larvae eaten inside by the parasitic wasp *Rogas nolophanae* (Fig. 36).

Bean leaf beetles are attacked by the parasitic fly *Celatoria diabroticae*. Parasitized beetles are not easy to detect, but one way to do so is to collect a dozen or two in a jar and add food. After a few days some of the beetles are likely to die. If the parasite is present, you will see small gray flies similar to house flies emerge from the bodies.

Green stink bugs are also hosts to several parasitic insects, the most important of which is the fly *Trichopoda pennipes*. The eggs of this fly can often be seen on the top of the bug's prothorax.

Fig. 35. Cocoon of *Apanteles marginiventris*, parasite of green cloverworms. 6X.

Fig. 36. Pupal case of *Rogas nolophanae*, parasite of green cloverworms. 4X.

Predators

The most common predators found in Illinois soybean fields are lady beetles (Fig. 37 A, B), lacewings (Fig. 38 A, B), and several bugs, notably *Orius insidiosus* (Fig. 39), *Nabis* spp. (Fig. 40), *Geocoris* sp. (Fig. 41), and *Podisus maculiventris*, the spined soldier bug (Fig. 42). Several species of predaceous ground beetles are also found in soybean (Fig. 43). Other common predators that prey indiscriminately on small insects are spiders (Fig. 44), praying mantises (Fig. 45), and some wasps (Fig. 46). Several species of predatory thrips and mites are efficient biological control agents of small, plant-feeding insects, mites, and their eggs.

Fig. 37 A. Lady beetle. 5X.

Fig. 37 B. Lady beetle larva. 4X.

James Sternberg

Fig. 38 A. Lacewing adult. 4X.

Courtesy of Union Carbide

Fig. 41. *Geocoris* adult. 10X.

Fig. 38 B. Lacewing larva. 4X.

Fig. 40. *Nabis* adult. 4X.

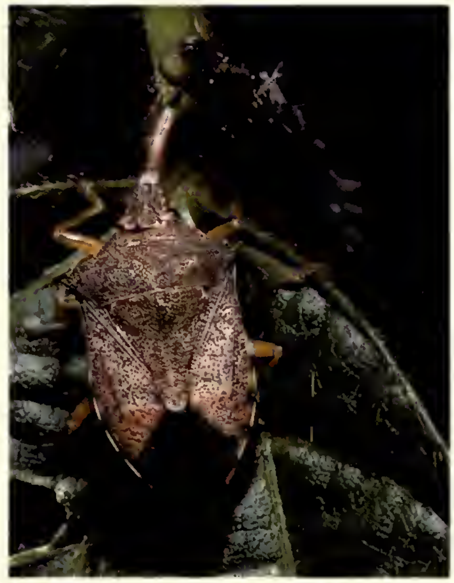


Fig. 42. Spined soldier bug preying on caterpillar. 3X.

Courtesy of Springer-Verlag

Fig. 39. *Orius insidiosus.* 12X.

James Sternberg

Fig. 43. Ground beetle. 5X.

Michael Jaffords

Fig. 44. Spider. 1.5X.

Fig. 45. Praying mantis. 0.8X.

Fig. 46. Predaceous wasp. 1.5X.

Diseases

Several disease organisms commonly infect soybean pests. Perhaps the most important natural control agent of the green cloverworm in Illinois is the fungus *Nomuraea rileyi* (Fig. 47). Lepidopterous caterpillars are infected by the spores of this fungus, and upon germination the mycelium completely fills the body cavity, killing the larva. The body becomes hard and mummified and is covered with a white layer of external conidiophores. Under hot, humid conditions the fungus sporulates, encasing the cadaver in powdery, light green spores. Detection of the disease may signal the decline of the pest population. It is therefore important that you recognize the presence and spread of the disease when surveying pest populations in soybean fields.

Fig. 47. Green cloverworm infected with *Nomuraea rileyi*. 1.8X.

Other diseases also infect many soybean pests. For instance, grasshoppers and woollybear caterpillars are frequently killed by fungi of the genus *Entomophthora* (Fig. 48). Certain diseases caused by microsporidians infest green stink bugs and bean leaf beetles. Because the effects are slower and less evident than those caused by fungi, these diseases may go undetected. However, they can be responsible for the death of hibernating individuals, thus reducing the size of colonizing generations the following year.

Fig. 48. Yellow woollybear larva infected with *Entomophthora*. 1X.

Crop Growth and Pest Occurrence

We now have information on the phenology (development and life history) of the most important soybean insect pests in Illinois and the annual cycle of the soybean crop. By superimposing one set of information on the other, we produced the chart in Figure 49. The annual cycle of four major pest species — stink bugs, green cloverworm, bean leaf beetle, and grasshoppers — are included in the chart. The three latter pests, plus sporadically occurring spider mites, account for nearly 85 percent of all the insecticide spraying that is done on soybean in Illinois. Stink bugs are potentially damaging in the southern half of the state. This chart should serve as a general guide for timing the operations in your pest management program. However, the curves are only averages; departures from the general trends are to be expected.

Since these curves are based on information collected in central Illinois, populations may peak one to two weeks earlier farther to the south, or one to two weeks later to the north. Depending on summer temperatures, there will also be annual fluctuations in the time of peak pest occurrence. A cool summer will cause a delay, represented by a shift to the right in the curves; a warmer than normal summer will result in a shift to the left.

Furthermore, the probability of outbreaks varies among regions within the state. From records of the past ten years we mapped the areas at risk for outbreaks of green cloverworm, bean leaf beetle, grasshoppers, spider mites, green stink bug, and Japanese beetle (Fig. 50). Most other pests occur only sporadically throughout Illinois.

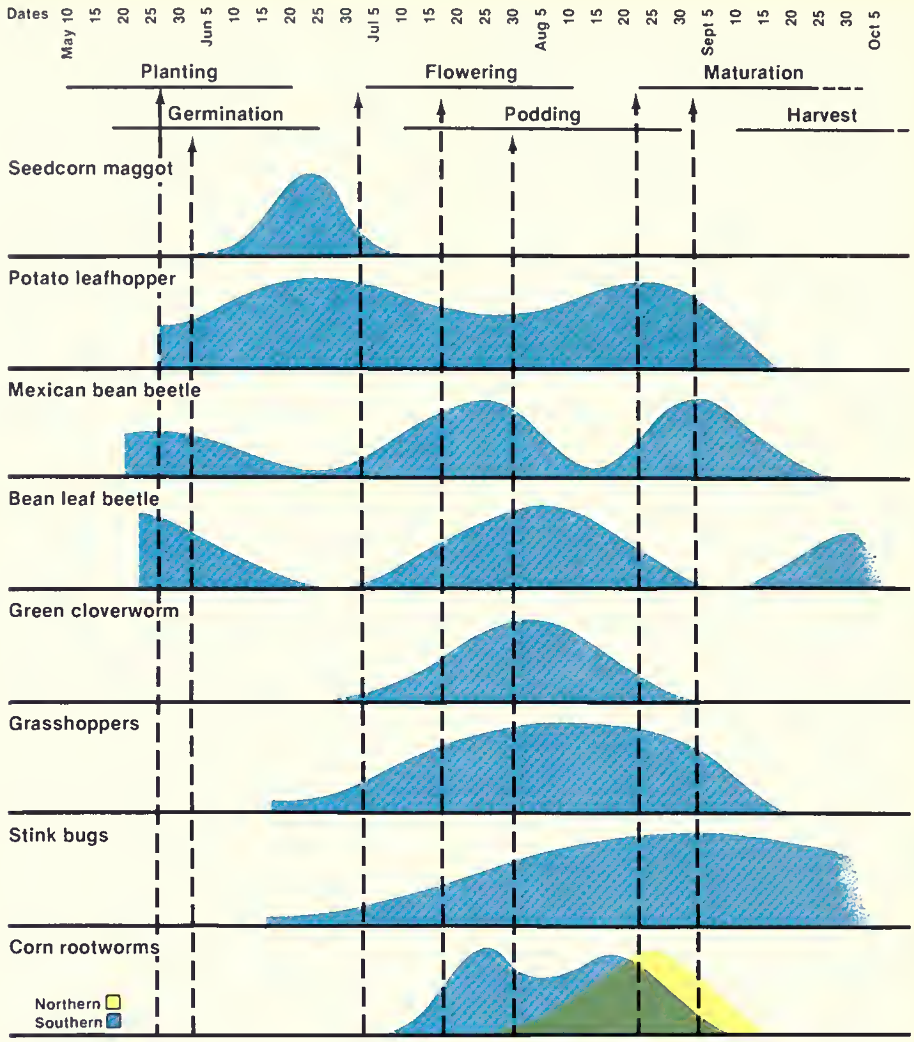


Fig. 49. Seasonal occurrence of some common soybean insects in Illinois.

Warning: The information in Figures 49 and 50 is merely a guide. Both timing and location of possible outbreaks may vary from year to year. It is therefore essential that you monitor pest occurrence in individual fields. Refer to the recommendations in these guidelines for efficient pest management.

Fig. 50. Areas of Illinois at risk for occurrence of major soybean insect pests.

The pest management program for soybean in Illinois requires field data for measuring insect pest populations, estimating the level of injury already caused by the pests, and evaluating natural controls in a field. With these data the program can provide criteria for helping you decide on control actions. If needed, controls consist mainly of selecting insecticides and applying them at dosages that are the most effective for given pests but least detrimental to beneficial parasites and predators.

The key factor in the pest management program is the correct measurement of pest populations. Sampling the populations, evaluating the biological control agents, and estimating plant injury are parts of the operation known as scouting. The three major components of the soybean pest management program are:

- Scouting
- Deciding on control actions
- Applying controls

Scouting

Insect pests invade soybean fields at different stages in the crop's growth cycle. To help you save time when scouting, we combined information about the soybean growth cycle in Illinois and the expected peak of occurrence of the main soybean pests in the state (Fig. 49). Soybean fields should be visited at least once after plant emergence and at least two or three times between the middle of July and the end of August. During this latter period, plants are extremely sensitive to defoliation, and most potential pests, particularly green cloverworm, bean leaf beetle, and grasshoppers, are expected to reach maximum levels.

Assessing insect populations

Various methods can be used for sampling insect populations. Because no single method is effective for all insect species or throughout the entire growing season, we compromised and used the ground cloth method, which is generally reliable and easy to adopt. The method is unsuitable, however, when surveying plants up to the V4 stage or when crops are planted at row widths of 15 inches or less.

Construction and use of the ground cloth are illustrated in Figures 51 and 52. After collecting the insects, count the ones that are predominant during that particular stage of plant growth. Record the number, because control recommendations are based on the number of insects per foot of row. Also look for predators, and note the number of caterpillars killed by disease.

Since samples are collected from 6 feet of row (3 feet on both sides of the ground cloth), five samples represent the insect population in 30 feet of row, or multiples of six if more samples are taken. To obtain the count per linear foot, the total number of insects collected in all samples is divided by the number of samples taken per field, times 6 (the number of row feet per sample). Thus:

Insects/foot of row =
no. insects in all samples ÷
no. samples × 6

The ground cloth should not be used until after the stand is well established (V4 stage). Before then, fields should simply be scanned to detect gaps in the stand. If gaps are observed, try to determine if insects are the cause. Several early season pests cut young plants at the hook or destroy seeds in the ground (see pages 6-7).

Use direct counts if foliage feeding, probably by bean leaf beetles, is observed early in the season. Direct count or direct observation is recommended while soybean plants are small (up to

stage V4). For this procedure, mark off a distance of 3 to 9 feet on the ground with the heel of your shoe. Then walk along the row between the two marks. Slowly turn the leaves upside down and unfurl the growing tips to locate any hidden beetles. It is also useful to tap the plants to dislodge beetles onto the ground. Count all beetles. To determine the insect population per linear unit of row, divide the number of insects by the number of feet measured on the ground. If done carefully, direct counts provide good estimates.

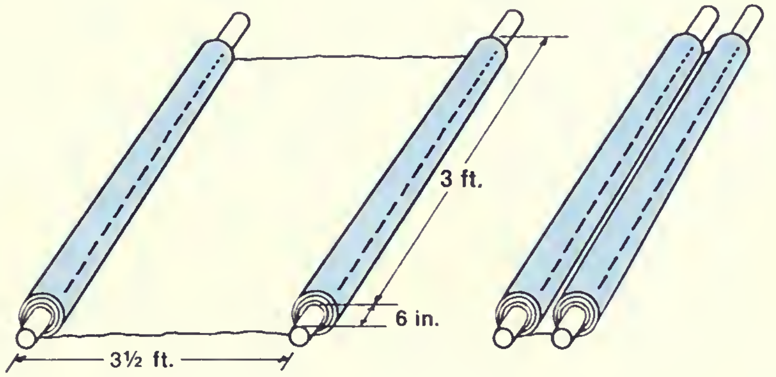


Fig. 51. Ground cloth construction. Use two 4-foot lengths of 1-inch dowel and piece of white canvas 3 feet by at least 3½ feet. Roll 3-foot side of canvas once around each stick and fasten with heavy-duty staples. Leave 6-inch handles at both ends of sticks.

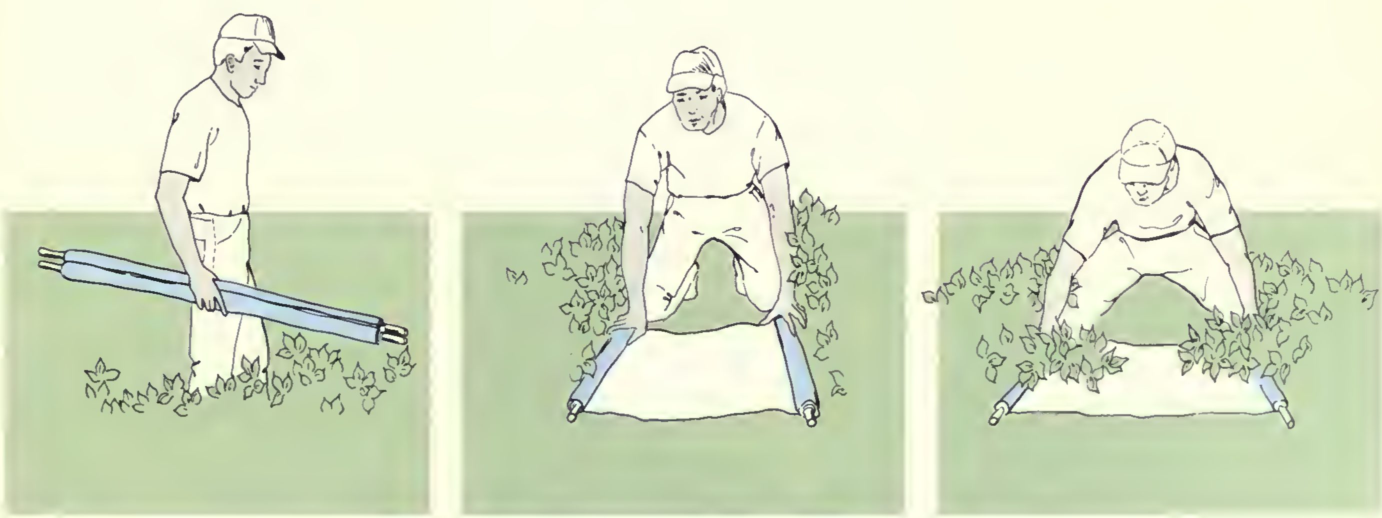


Fig. 52. Sampling procedure. **(A)** Keep cloth rolled up while slowly approaching sampling site. Walk along row space next to chosen site to avoid disturbing the insects. **(B)** Carefully move to face site. Put cloth, still rolled, between two rows. Quickly unroll cloth and hold sticks in place with knees. **(C)** Shake plants from each row over cloth. Release plants and quickly look for caterpillars or beetles clinging to fallen leaves.

Sweepnet sampling is recommended for soybean planted at row spacings too narrow for the ground cloth to be used properly. Construction of a sweepnet is illustrated in Figure 53; the nets are also available commercially. Sampling results obtained with the sweepnet are often difficult to interpret because they give only a relative estimate of a population. However, if you always sample carefully in the same way, you'll learn to interpret the results so that relative counts can be converted to absolute estimates.

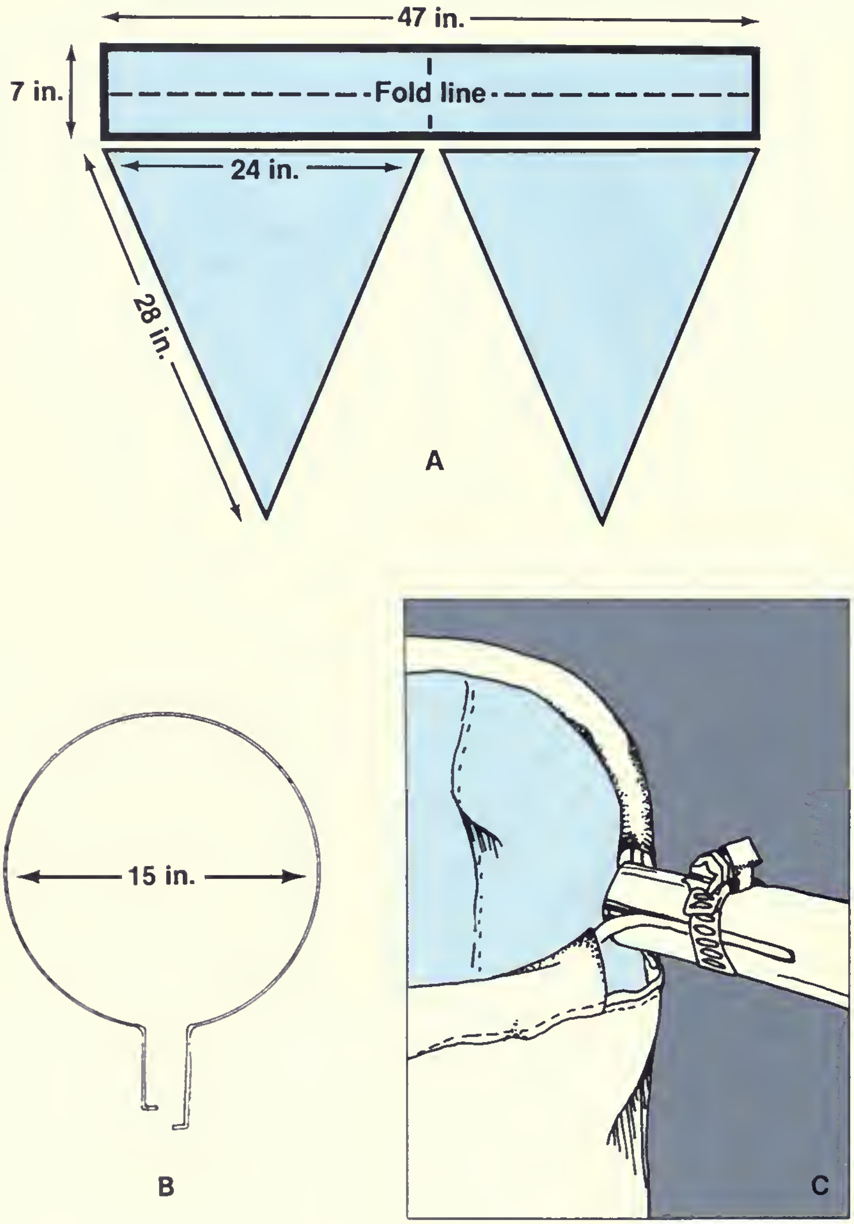


Fig. 53. Sweepnet construction. Use white canvas or muslin for net, No. 6 to No. 8 gauge wire for hoop, and light but strong wood for handle. **Net (A)** Sew two triangles together along side edges. Fold and sew band around top of net. A gap of about 2 inches should be left between ends of band for inserting hoop **(C).** Allow ½ inch for all seams. **Hoop (B)** Shape hoop as indicated, making one stem ½ inch longer than the other. **Handle (C)** On opposite sides of handle make grooves for stems. Thread hoop through band of net, press stems of hoop into grooves and fasten securely with hose clamp.

In narrow-row or solid plantings of soybean we recommend the use of the "sweeps across" method, which is explained in Figure 54. Each swing of the net is counted as one sweep, and each sampling unit should consist of at least 20 sweeps. Twenty sweeps cover about 40 feet of row, but in most cases you'll collect only 30 to 40 percent of the actual population, and even less if plants are badly lodged. Thus the counts must be adjusted accordingly.

If the field is in 7-inch row widths, the hoop of the net, which covers a swath of about 15 inches, will include four or five rows with each stroke. Adjustments for these factors are included in the conversion of number of bugs per 20 sweeps to number of bugs per foot of row as follows for 7-inch rows:

no. insects/foot of row =
no. insects/20 sweeps × 0.02

Or for 15-inch rows:

no. insects/foot of row =
no. insects/20 sweeps × 0.04

The optimal number of samples per field varies with the characteristics of the insect species, population density, sampling procedure, and size of the field. As a rule of thumb, however, it suffices to take one ground cloth sample or one set of direct counts (3 to 9 feet of row) for every 10 acres, but never less than five samples per field. Location of sampling sites in fields of various shapes is shown in Figure 55.

The best method, known as the sequential sampling plan, allows you to adjust the number of samples according to the four variables mentioned above (insect species, population density, and so forth).

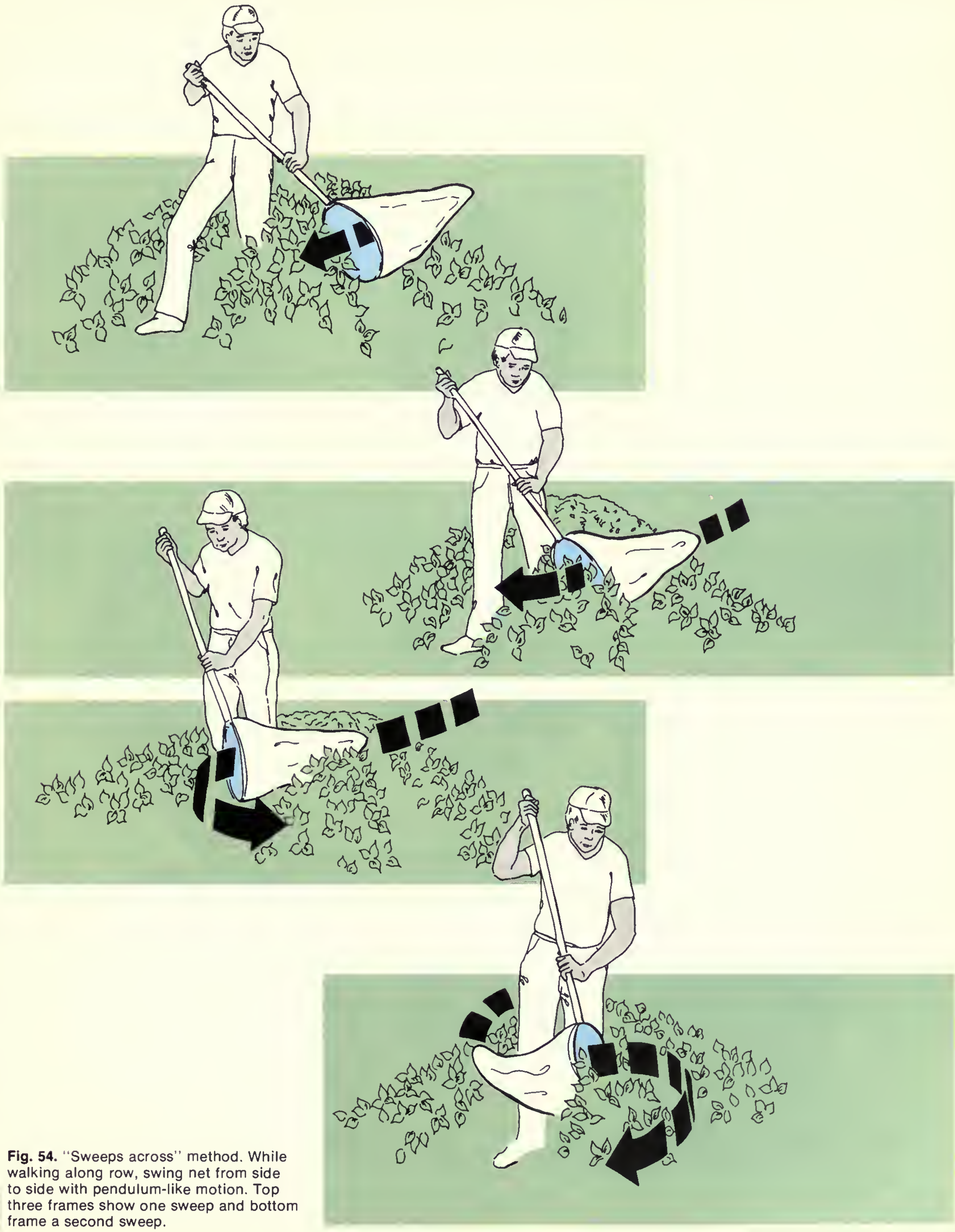


Fig. 54. "Sweeps across" method. While walking along row, swing net from side to side with pendulum-like motion. Top three frames show one sweep and bottom frame a second sweep.

Evaluating biological control agents

Predatory bugs, lady beetles, and lacewing larvae are among the most common predators of soybean pests. In addition to these rather large insects, there are many species of predatory thrips and mites, as well as a multitude of parasitic wasps and flies that are not easily detected by the untrained observer. Many of these beneficial insects are present in numbers capable of keeping pest populations below the economic injury level.

Pest management programs are designed to protect these predators and parasites and to gain maximum benefit from their activities. Scouts and growers should learn how to distinguish the beneficial from the harmful insects. Some of the most common species are pictured on pages 41 to 43.

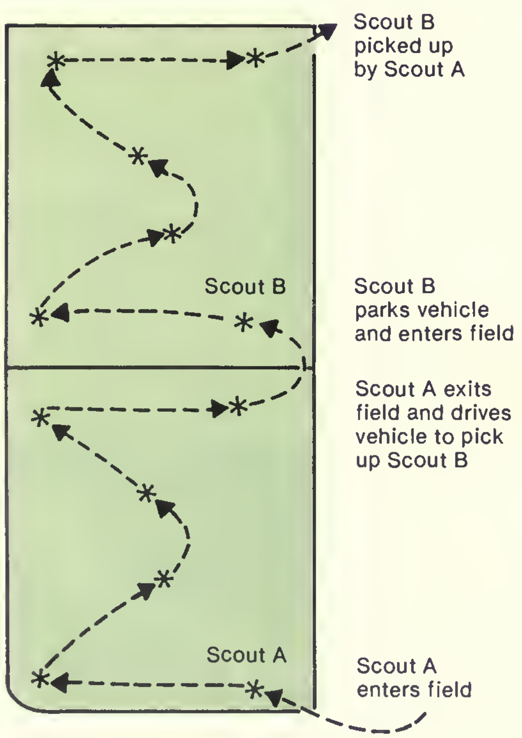
Fungal diseases are very effective natural controls. The fungus *Nomuraea rileyi*, for example, provides perhaps the most efficient control of green cloverworms in outbreak years. Use the ground cloth method to detect diseased larvae. Look for either white, conidiophore-filled cadavers (Fig. 47) or sluggish larvae that, unlike healthy ones, do not twitch when dropping to the ground. Record the number of diseased larvae separately from the number of apparently healthy ones. These records are important in the detection of disease outbreaks.

On many occasions, green cloverworm populations that were nearing the economic injury level have been completely wiped out by this fungal disease. If the fungus is spreading, an insecticide application may be saved. The presence of predators, and particularly a spreading fungal disease, should be taken into account in the decision-making phase of the pest management program.

Measuring injury

Sampling the populations and evaluating the biological control agents are the first two sets of observations to be noted when scouting soybean fields. The third set of observations is the amount of plant injury already present. Described in the section on "Injury to Soybean," the types of measurable damage used in the IPM program are seedling destruction, defoliation, and pod and seed injury.

Seedling destruction and reduction of the stand are easily identified. But keep in mind that moderate seedling injury causing growth retardation can be overestimated. In general, if growing conditions are favorable, plants will compensate for injury early in the season unless cotyledons and unifoliolates are completely destroyed. A careful examination of plants at the seedling stage is necessary for making correct



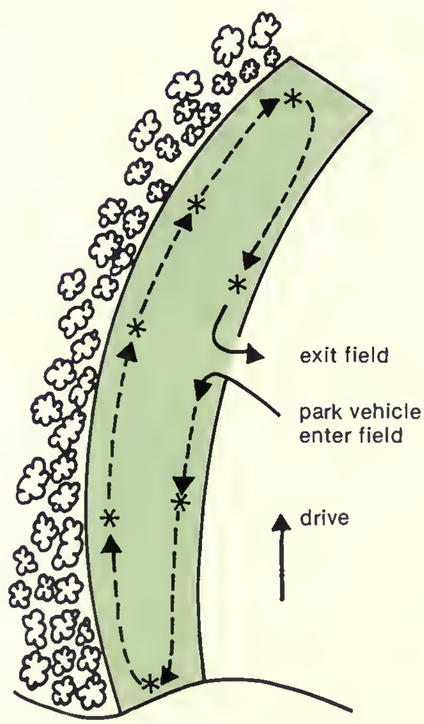


Fig. 55. Efficient procedures for scouting large fields.

control decisions.

Defoliation may result from hail, wind, and diseases, which often substantially reduce the functional leaf area of the crop. Insects produce direct defoliation or aggravate the effect of other defoliating factors. For instance, a leaf with a hole is more likely to tear under the force of the wind than a leaf with an unblemished surface. For the IPM system you need to estimate the overall level of defoliation regardless of cause, because the various types of defoliation are essentially additive.

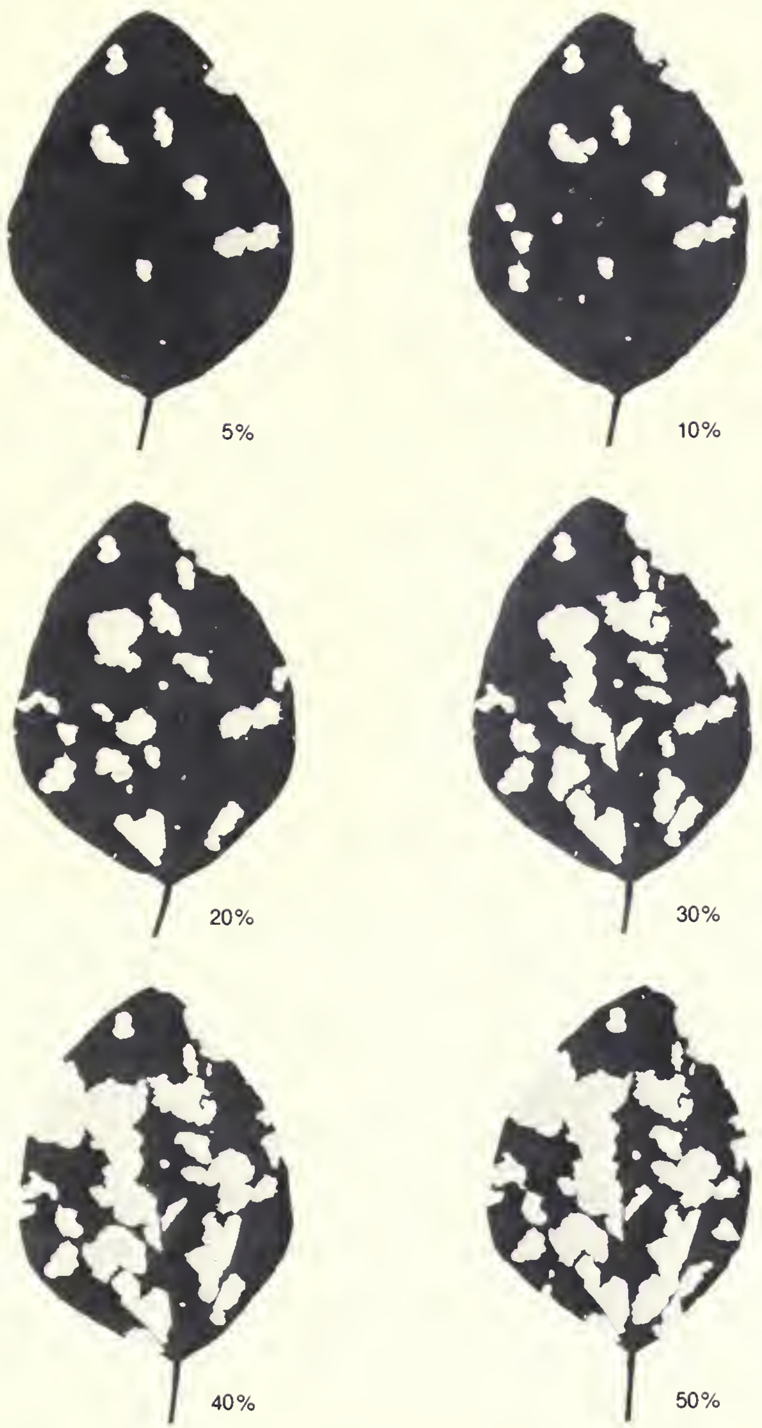


Fig. 56. Levels of defoliation of soybean leaflets eaten by a green cloverworm larva. This figure should be used to help calibrate estimates of defoliation.

To estimate defoliation, surveyors and scouts need to learn how to scan the plants from top to bottom while walking through a field. Inexperienced scouts tend initially to overestimate defoliation. In training sessions it is useful to allow individuals within groups of trainees to make their own estimates and then compare estimates of the entire group. With adequate guidance from more experienced scouts, a person can learn to estimate defoliation with reasonable ease.

Another, although more time-consuming, way is to "calibrate" estimates. The method includes three steps:

1. Without looking at the plants, stretch out your arm and collect at random 20 leaflets each from the top, middle, and bottom thirds of scattered plants in the field, for a total of 60 leaflets.

2. Compare the leaflets with the set in Figure 56, which illustrates insect-produced defoliation at six increments.

3. Record your estimates of the percent defoliation for each of the 60 leaflets and take the mean (add up the estimates and divide the total by 60). The result is the overall defoliation level in the field.

Pod and seed injury is measured by harvesting 100 pods from various parts of plants in scattered areas of the field. The number of injured pods is tallied, thus providing the percent injury for the entire field. Grasshopper feeding and scars caused by bean leaf beetles are very easy to detect, but moderate injury by stink bugs may go undetected. Therefore, decisions on stink bug control are based solely on counts of adults and large nymphs.

Forecasting

Scouting fields is the surest way to monitor the status of pests. However, insect pests on soybean are sporadic in most parts of Illinois. In some years few if any insects injure the crop. When this is the case, the effort and expense of scouting could be saved if we were able to predict early in the season whether an outbreak in a given region is likely to occur.

Forecasting pest outbreaks is not easy. We are, however, building into the IPM program a forecasting capability for bean leaf beetle, green cloverworm, and grasshoppers. The capability is based on having entomologists take samples early in key areas of the state. These data are then used in computerized simulation models, along with actual weather data from the various crop-reporting districts.

The information derived from the models will be passed on to the Cooperative Extension Service for delivery to the farming community. We suggest that you subscribe to the "Insect, Weed & Plant Disease Survey Bulletin," published weekly by the Illinois Cooperative Extension Service, and tune in to radio and TV programs of agricultural news in your area. Use this information advisedly, because biological phenomena can be predicted only within certain margins of probability.

Control Tactics

The central idea in IPM is to take maximum advantage of all available control methods. An IPM program aims at combining various methods or tactics into a regionally suitable control strategy. The main tactics used are biological control, cultural control, plant resistance, and chemical control.

Biological control

Biological control is the manipulation of parasites, predators, and diseases in a manner that helps these natural agents keep pest populations below the economic threshold. Most soybean insect pests in Illinois have efficient natural enemies that need no manipulation. Our main concern is not to disturb them by the misuse of insecticides. We therefore recommend the careful selection of insecticides that are least likely to disrupt biological control agents.

Cultural control

Every grower must take into account the possible effect of agricultural practices on pests. Special cultural procedures have been designed specifically for the control of damaging insects, but we are interested here in the effects of normal farming operations on pests.

Tillage usually exposes many soil-dwelling insects, such as white grubs and wireworms, to birds and other predators. But the effect that minimum or no tillage may have on these pests is not well known. You should be aware of potential problems and carefully monitor changes in the incidence of the pests after adopting reduced tillage practices.

Crop rotation is recommended for sound economic and agronomic reasons. Planting soybean continuously seems to have little effect on insect pests, but the practice does lead to increasingly serious problems with diseases and nematodes. For good integrated pest management, crop rotation should be practiced in accordance with university agronomic recommendations.

Planting dates are dictated by climatic conditions. We do not recommend changes in established planting dates to control insects. But bear in mind that early planting favors the bean leaf beetle and that double cropping, by

Fig. 57. Clark soybeans in foreground are hairless and are susceptible to the potato leafhopper; plants in the middle have curly hairs and are moderately susceptible; those in background have normal hairs and are resistant.

extending the growing cycle of plants in certain regions, may result in greater pod and seed damage by stink bugs, grasshoppers, and the bean leaf beetle. Careful scouting of a late maturing crop is therefore necessary.

Plant resistance

Most soybean varieties recommended in Illinois are highly resistant to the potato leafhopper, mainly because the plants are hairy. Glabrous (hairless) lines are severely stunted by the leafhopper (Fig. 57). Considerable resistance to the most common diseases has been incorporated into practically all of the recently developed varieties, and some are now being bred for greater resistance to nematodes and defoliating insects. Eventually the IPM program will add newly developed varieties that combine high yields with increased pest resistance.

Chemical control

If pest populations reach the economic threshold, the only remedial tactic in IPM for soybean is the well timed application of selective insecticides. Scouting provides the information needed to arrive at decisions about control and timing. Selectivity is obtained with carefully chosen insecticides and rates of application.

According to the research, most soybean pests can be adequately controlled with lower dosages than those previously recommended by the university or the manufacturer. The lower dosages are less detrimental to biological control agents. The rates recommended in 1973 and 1977 in most soybean-producing states are shown in Table 6.

We have not included insecticide control recommendations in these guidelines, because insecticides and dosages may change from year to year. For annually revised recommendations, consult the current issue of Circular 899, "Insect Pest Management Guide: Field and Forage Crops," published by the Illinois Cooperative Extension Service. Always follow label directions when using an insecticide, and always have in hand a copy of the "Illinois Pesticide Applicator Study Guide," also published by the Cooperative Extension Service.

Table 6. Insecticide Dosages Recommended for Control of Soybean Pests, 1973 and 1977

Species	Insecticides	Recommended rate, lb a.i./acre 1973	1977
Bean leaf beetle	Carbaryl	1.50	0.50
	Methyl parathion	0.50	0.25
	Azinphosmethyl	0.25	0.125
Green cloverworm	Carbaryl	1.50	0.50
	Methyl parathion	0.50	0.25
	Bacillus thuringiensis	...	0.25-0.50
Stink bugs	Carbaryl	1.50	...
	Methyl parathion	0.50	0.25-0.50

Adapted from: D. L. Newsom *et al.* 1980. *New Technology in Pest Control*, ed. C. H. Huffaker, p. 89. New York: John Wiley & Sons.

Decision Charts

Information gathered through scouting is used in deciding whether to spray and when. The stage of crop growth and general condition of the field should also be taken into account.

Early in the season, insecticide applications for bean leaf beetles and baits for cutworms may be required. No specific preventive use of soil insecticides is recommended for soybean.

Control decisions for bean leaf beetle are shown in Table 7. If the stand is reduced below the tolerable levels presented in Tables 2 and 3, some replanting may be necessary. In case insects such as white grubs, wireworms, or cutworms are responsible for the damage, you may need to apply soil insecticides or insecticide baits in the areas to be replanted.

Mid-season pests are mainly defoliators such as green cloverworms and bean leaf beetles. Control decisions for green cloverworm are shown in Table 8. Seldom is it necessary to spray solely for control of bean leaf beetles, although their feeding may contribute to the overall level of defoliation. Spraying for green cloverworms will probably take care of any concurrent infestation of bean leaf beetles.

Late season pests are pod feeders, especially bean leaf beetles, grasshoppers, and stink bugs. For stink bug control, follow the economic thresholds in Table 5. For decisions about bean leaf beetle control during the stages of seed maturation see Table 9.

Table 7. Decision Chart for Control of Bean Leaf Beetle on Soybean at Seedling Stage Through Early Vegetative Growth (VE to V3)[a]

Injury level	No. of beetles per foot of row		
	Less than 4	4 to 6	More than 6
Cotyledons slightly injured; less than 30 percent injury to unifoliolate and open trifoliolates	Sample again by late July	Sample again within 1 week	Sample again in 3 days
At least one cotyledon completely destroyed; 30 to 40 percent injury to unifoliolate and open trifoliolates	Sample again in 3 days	Spray (correct time); no loss expected	Spray (overdue)
Two cotyledons destroyed; more than 40 percent defoliation	Sample in 3 days; if plants are dying, some replanting may be needed	Spray; if plants are dying some replanting may be needed	Spray; if plants are dying, some replanting may be needed

[a] To use this table, first sample the field to determine the pest population level and the injury level. Use direct counts on 3 feet of row to sample bean leaf beetles on seedlings (see pages 46-47).

Table 8. Decision Chart for Control of Green Cloverworm on Soybean After Full Bloom and Before Seed Maturation (R1 to R5)[a]

Defoliation, percent	No. of cloverworms[b] (more than ½ in. long) per foot of row		
	Less than 8	8 to 12	More than 12
0 to 20	Continue sampling at regular intervals (10 to 12 days)	Continue sampling at closer intervals (3 to 5 days)	Spray (preventive); low probability of loss
20 to 30	Continue sampling at closer intervals (3 to 5 days)	Spray (correct time); no loss	Spray (overdue); probability of minor loss
Over 30	Continue sampling at closer intervals; probability of loss but population in decline	Spray (overdue); probability of loss	Spray (much overdue) probability of major loss

[a] To use this table, first sample the field to determine the pest population level and the percent defoliation. See pages 46 to 48 for sampling procedures.
[b] The amount of injury caused by one green cloverworm is approximately equal to that produced by two bean leaf beetles or ½ grasshopper. Thus, to compute thresholds for bean leaf beetles, multiply the level in the above footnote by 2; to compute thresholds for grasshoppers divide the levels above by 2.

Table 9. Decision Chart for Control of Bean Leaf Beetle on Soybean at Stage of Seed Maturation Through Harvest Maturity (R6 to R7)[a]

Pod injury, percent	No. of beetles per foot of row		
	Less than 8	8 to 10	More than 10
0 to 8	Discontinue sampling	Sample again in 5 days	Spray (preventive if pods are still green)
8 to 12	Sample again in 5 days	Spray if pods are still green or beginning to yellow	Spray if pods are beginning to yellow
Over 12	Spray if pods are still yellow and beetles are present	Spray unless pods are completely dry	Spray unless pods are completely dry

[a] To use this table, first sample the field to determine the pest population level and the percent pod injury. Use a ground cloth to sample the beetles (see pages 46-47). Collect 20 pods at random in 5 different locations in the field to obtain the percent pod injury.

Implementing the Pest Management Program

The pest management program is referred to as integrated because various control tactics are coordinated into a control strategy that is economically and ecologically sound. To develop IPM, however, we also need an integration of efforts. If IMP is to be successful, everyone interested in either the public or the private aspects of agricultural production must communicate and work together as an integrated team. This team is composed of the grower, county Extension adviser, pest management consultant and scouts, and Extension and research entomologists. Each member of the team has an important role.

Growers

Growers are the ultimate decision makers and users of IPM and hence should be the primary beneficiaries of the program. After having adopted IPM, they do their own scouting or decide to hire a pest manager or professional scouts. With the IPM guidelines, growers will be able to scout their fields more efficiently, avoid unnecessary insecticide applications, and profit from the better timing of those applications that are needed.

County Extension Advisers

Extension advisers play a dual role in IPM. First, they alert growers to the benefits of using IPM, explain the techniques, and offer help in making IPM decisions. Second, the advisers communicate to Extension and research entomologists the success and failures of IPM procedures. Their collection of data on insecticide use in each county is essential in helping to plot long-range pest trends. Because IPM is dynamic, its improvement requires constant feedback. County Extension advisers are in a unique position to promote interaction between growers and other members of the team.

Pest Management Consultants

Well trained consultants can serve the farming community by monitoring the pest situation and level of injury and by assisting in the task of making control decisions. As the IPM program becomes more sophisticated and complex, the role of professional consultants will become increasingly important. Feedback from their field experiences to the professional entomologists in Extension and research is essential for the continued improvement of the program.

Extension and Research Entomologists

Research and Extension entomologists work together to identify pest problems, evaluate the effects of various pests, and define economic thresholds. The entomologists also monitor pest trends for the forecasting program and design improved control techniques. As farming systems change, updating of IPM programs is necessary. For instance, switching to narrower row spacings requires a suitable method for sampling pest populations. Researchers are responsible for developing the appropriate technology.

But the entire research effort is worthless if the findings are not effectively communicated to potential users, namely, growers, advisers, and consultants. Thus research and Extension must cooperate to guarantee an uninterrupted flow of information.

Implementation in Steps

The first seven sections of these guidelines contain information on the main soybean insect pests in Illinois, methods for measuring pest populations and injury levels, and charts and economic thresholds to help you decide if and when to apply insecticides. The section that follows summarizes the steps for implementing the integrated pest management program.

1

Plant quality seed at the proper depth and adequate density for the selected row spacing.

2

Avoid problems of plant injury from herbicides that carry over or from herbicides and insecticides that are incompatible.

3

Scout fields early in the season for bean leaf beetles, cutworms, and seedcorn maggots (see pages 22-23, 31, and 38). Refer to Tables 2 and 3 for injury tolerances and to Table 7 for control decisions.

4

Follow the weekly pest predictions in the "Insect, Weed & Plant Disease Survey Bulletin" and the recommendations of Extension specialists in Circular 899, "Insect Pest Management Guide: Field and Forage Crops."

5

After July 1 be on the alert for radio and TV warnings about outbreaks of green cloverworms, bean leaf beetles, or grasshoppers in your region. If warnings are given, scout your fields to estimate pest populations (see pages 46-50) and to evaluate the presence of natural enemies, especially the fungal diseases (see page 50). Estimate defoliation levels and determine the growth stage of your crop (see Table 1 and pages 50-51). Refer to the decision chart in Tables 4 and 9 for economic thresholds.

6

If fields go through a droughty period for 18 to 21 days during July and August, check for spider mite outbreaks (see page 40), particularly in western and southwestern Illinois. If patches of plants are being killed in the field, follow the current control recommendations in Circular 899.

7

If no special pest warnings are issued for your region, check your fields once during late July or early August for first-generation bean leaf beetles, green cloverworms, and grasshoppers (see pages 22-23, 33-34, and 36).

8

If populations and defoliation levels approach the economic threshold (Tables 4 and 8), be prepared to apply an insecticide spray. Refer to Circular 899 for dosages and precautions.

9

In late August and September beware of second-generation bean leaf beetles, stink bugs, and grasshoppers feeding on pods (pages 22-23, 29-30, and 36). Refer to Table 5 for economic thresholds, to Table 9 for control decisions, and to Circular 899 for insecticide recommendations.

10

Integrated pest management is a global strategy for controlling weeds and diseases as well as insects. Although we stress insects in these guidelines, the calendar on page 58 serves as a preliminary guide for a broader crop management program. Expand on this scheme to meet the needs of your farming operation.

11

Use these guidelines frequently to identify less common insects and to distinguish beneficial natural enemies from pest species. Help us improve the guidelines by informing state Extension and research entomologists about new pest problems and about the results of the IPM program in your region.

Illinois Soybean Cropping System

Crop Management Schedule

		Agronomic practices	Insect control	Weed control	Nematode control	Disease control
Pre-season activities	Jan Feb Mar Apr	Planting plans Acreage Field selection Variety selection Fertilizers Pesticides Equipment	Rotation Resistant varieties Insecticides[a]	Rotation Herbicides[b]	Rotation Resistant varieties Nematicides[b]	Rotation Resistant varieties Disease-free seed Fungicides[b]
Planting	May	Soil preparation Conven-tional / Mini-mum or No-till Planting Row spacing Fertilization		Herbicides Pre-plant / Pre-emerg.	Nematicide application	
	Jun	Stand estab-lishment [Replanting]	Scouting If early season pests are present, spray recommended insecticide (see Tables 4 and 7 for economic thresholds)	Rotary hoeing Weed survey Post-emerg. herbi-cide / Culti-vation		
Growing season	Jul		Scouting If mid-season pests are present, spray with recommended insecticide (see Tables 4 and 8 for economic thresholds)	Row cultivation [Hand weeding]		Disease monitoring If mid-season diseases are present, start spray schedule
	Aug		Scouting If late season pests are present, spray with recommended insecticide (see Tables 5 and 9 for economic thresholds)	Weed mapping		Disease monitoring If late season diseases are present, apply fungicides
Harvesting	Sep Oct	Harvesting Storage Fall plow-ing / No-till			Soil surveys	
Post-season activities	Nov Dec	Marketing Maintenance of equipment		Planning Rotation Herbicides Cultural practices	Planning Rotation Resist. var. Nematicides	

[a] For insecticide recommendations see Circular 899.
[b] Consult Illinois Cooperative Extension Service publications for pesticide recommendations.